This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Stanford University Libraries
3 6105 007 942 837

S3726

SCHOOL OF EDUCATION
LIBRARY

EDUCATION
BOOK PURCHASE
FUND

STANFORD UNIVERSITY
LIBRARIES

School Science

A Journal of Science Teaching in Secondary Schools.

Volume II,
1902=1903.

EDITED BY C. E. LINEBARGER.

ASSOCIATE EDITORS:

FRANKLIN W. BARROWS (*Physiology*),
Central High School, Buffalo, N. Y.

E. C. CASE (*Geology*)
State Normal School, Milwaukee, Wis.

H. N. CHUTE (*Physics*),
High School, Ann Arbor, Mich.

R. H. CORNISH (*Physiography*),
Girls' High School, New York City.

E. L. HILL (*Biology*),
Collegiate Institute, Guelph, Ont., Can.

E. L. MORRIS (*Biology*),
Western High School, Washington, D.C.

LOUIS MURBACH (*Biology*),
Central High School, Detroit, Mich.

GEORGE W. MYERS (*Astronomy*),
School of Education, University of Chicago

LYMAN C. NEWELL (*Chemistry*),
State Normal School, Lowell, Mass.

WM. H. SNYDER (*Geography*),
Worcester Academy, Worcester, Mass.

GEORGE F. STRADLING (*Physics*),
N. E. Manual Training School, Philadelphia

RUFUS P. WILLIAMS (*Metrology*),
English High School, Boston, Mass.

RAVENSWOOD, CHICAGO.

The School Science Press,

1903.

LELAND

LIBRARY
LELAND STANFORD JR.
UNIVERSITY

Index to Volume II.

1902-1903.

MARCH, 1902, TO APRIL, 1903.

A

Accelerated Motion, A Diagram Illustrating. HERMAN D. STEARNS..... 334
Accelerated Motion, Some Improvements in Apparatus for. E. E. BURNS..... 286
Agriculture, Elements of in the High School Course. RICHARD RUNKE..... 282
Amoebae, A Method for Collecting. S. O. MAST..... 407
Aquarium Cement, Formula for. S. O. MAST..... 128
Arc Lights, The Singing and Speaking. K. E. GUTHE..... 209
ASHMAN, GEORGE C. A Method of Determining the Relative Amounts of Oxygen and Nitrogen in the Atmosphere..... 155
Astronomy, Elementary Experiments in Observational. GEORGE W. MYERS..... .....35, 107, 169, 223, 288
Atmosphere, A Method of Determining the Relative Amounts of Oxygen and Nitrogen in the Air. GEORGE C. ASHMAN..... 155
Atomizer, A Simple. L. MURBACH..... 358
Auxanometer, A Simple. L. MURBACH..... 346

B

Baking Powders, Examination of. WARREN RUFUS SMITH.....342
Balance Details. E. C. WOODRUFF..... 29
BARNES, C. R. Plant Physiology in the High School..... 320
BARROWS, FRANKLIN W. Biology in American Colleges—Its Methods and Objects 19, 82
BEEBE, S. P. Formation of Sulphur Dioxide for Laboratory Students..... 115
BIGELOW, M. A. The European Edible Snail..... 405
Biological Laboratory, Plans for a. S. O. MAST..... 166
Biology in American Colleges—Its Methods and Objects. FRANKLIN W. BARROWS 19, 82
Boiling Point, An Experiment Showing the Relationship Between Pressure and. C. E. LINEBARGER 156
BOOK REVIEWS. Alembic Club Reprint, No. 16; Ladenburg's Lectures on the Development of Chemistry since the Time of Lavoisier, 539; Animal Activities, N. S. French; Elementary Plant Physiology, D. T. MacDougal, 182; Essentials of Chemistry, John C. Hessler and Albert L. Smith, 360; Guide to Preparation Work in Inorganic Chemistry; Reinhard Blochman, translated by Jas. Lewis Howe, 416; Laboratory Outline of General Chemistry, Alexander Smith, 416; Laboratory Manual in Elementary Biology, Frederick DeForest Heald, 238; Laboratory Exercises in Elementary Physics, Franklin H. Ayres, 181; Invertebrate Zoology, H. S. Pratt, 117; Nature Study for Grammar Grades, W. S. Jackman, 539; Outlines of Botany for the High School Laboratory and Class Room, R. G. Leavitt, 238; Physiology by the Laboratory Method, Wm. J. Brinckley, 361; The Science of Mechanics, Ernst Mach, translated by T. J. McCormack, 362; Suggestions for Pro-

70784

LIBRARY
LELAND STANFORD JUNIOR
UNIVERSITY

Index to Volume II.

1902-1903.

MARCH, 1902, TO APRIL, 1903.

A

Accelerated Motion, A Diagram Illustrating. HERMAN D. STEARNS..... 334
Accelerated Motion, Some Improvements in Apparatus for. E. E. BURNS..... 286
Agriculture, Elements of in the High School Course. RICHARD RUNKE..... 282
Amoebae, A Method for Collecting. S. O. MAST..... 407
Aquarium Cement, Formula for. S. O. MAST..... 128
Arc Lights, The Singing and Speaking. K. E. GUTHE..... 209
ASHMAN, GEORGE C. A Method of Determining the Relative Amounts of Oxygen and Nitrogen in the Atmosphere..... 155
Astronomy, Elementary Experiments in Observational. GEORGE W. MYERS..... .....35, 107, 169, 223, 288
Atmosphere, A Method of Determining the Relative Amounts of Oxygen and Nitrogen in the Air. GEORGE C. ASHMAN..... 155
Atomizer, A Simple. L. MURBACH..... 358
Auxanometer, A Simple. L. MURBACH..... 346

B

Baking Powders, Examination of. WARREN RUFUS SMITH.....342
Balance Details. E. C. WOODRUFF..... 29
BARNES, C. R. Plant Physiology in the High School..... 320
BARROWS, FRANKLIN W. Biology in American Colleges—Its Methods and Objects 19, 82
BEEBE, S. P. Formation of Sulphur Dioxide for Laboratory Students..... 115
BIGELOW, M. A. The European Edible Snail..... 405
Biological Laboratory, Plans for a. S. O. MAST..... 166
Biology in American Colleges—Its Methods and Objects. FRANKLIN W. BARROWS 19, 82
Boiling Point, An Experiment Showing the Relationship Between Pressure and. C. E. LINEBARGER 156
BOOK REVIEWS. Alembic Club Reprint, No. 16; Ladenburg's Lectures on the Development of Chemistry since the Time of Lavoisier, 539; Animal Activities, N. S. French; Elementary Plant Physiology, D. T. MacDougal, 182; Essentials of Chemistry, John C. Hessler and Albert L. Smith, 360; Guide to Preparation Work in Inorganic Chemistry; Reinhard Blochman, translated by Jas. Lewis Howe, 416; Laboratory Outline of General Chemistry, Alexander Smith, 416; Laboratory Manual in Elementary Biology, Frederick DeForest Heald, 238; Laboratory Exercises in Elementary Physics, Franklin H. Ayres, 181; Invertebrate Zoology, H. S. Pratt, 117; Nature Study for Grammar Grades, W. S. Jackman, 539; Outlines of Botany for the High School Laboratory and Class Room, R. G. Leavitt, 238; Physiology by the Laboratory Method, Wm. J. Brinckley, 361; The Science of Mechanics, Ernst Mach, translated by T. J. McCormack, 362; Suggestions for Pro-

70784

gressive and Correlative Nature Study, G. W. Carver, 240; Supplementary Readings in Physics, J. A. Culler, 48; The Teaching of Chemistry and Physics, Alexander Smith and Edwin H. Hall, 336; University Textbook of Botany, D. H. Campbell, 238.
Botany, High School. V. A. SUYDAM.....435, 500
Botany. Notes on the Study of Seeds. GILBERT H. TRAFTON..... 237
Botany, A Standard College Entrance Option in..... 159
BROWN, MARION R. The History of Zoology Teaching in the Secondary Schools of the United States.....201, 256
BROWNELL, HERBERT. Science Teaching for the High School..... 251
BURCHARD, ERNEST F. The Volumetric Synthesis of Water as a Practical Quantitative Lecture Experiment..... 460

C

CAPLIN, JESSIE F. Per Cent of Nitrogen in Air; To Show that Oxidation Means Increase in Weight..... 302
CARHART, HENRY S. Revision of Physical Theory..... 371
CASE, E. C. Another Heliotrope..... 101
Chemistry in Education. C. L. SPEYERS.....70, 133
Chemistry, Notes on the Progress of. LYMAN C. NEWELL..... 229
Chemistry, The Planting of, in America. RUFUS PHILLIPS WILLIAMS.....75, 139
Circulation of the Blood. W. H. MANWARING..... 28
Cocoanut—Its Composition and Germination. J. E. KIRKWOOD..... 401
Composition of Forces, Details of an Experiment in. W. C. HAWTHORNE..... 26
COOPER, HERMON C. The Lime Water Test for Carbon Dioxide..... 302
Corn or Glucose Syrups. EDWARD GUDEMAN..... 22
CORNISH, R. H. Matter and Method in Physics Teaching.....327, 387
CORRESPONDENCE 250, 369, 428, 486, 545
Courses in Chemistry and Physics in New York High Schools. M. D. SOHON.... 419
CURTIS, HARVEY L. The Use of the Jolly Balance in Calorimetry Experiments... 337

D

Decadence of the Vulgar Fraction. RUFUS P. WILLIAMS..... 41
Decimal Coinage, How Uncle Sam Got a. WILLIAM H. SEAMAN.....232, 292
DENNIS, L. M. What of Chemistry Shall Be Taught in the High School, and How Shall It Be Most Effectually Taught?..... 546
Determination for the Weight of a Liter of Air, The. C. E. LINEBARGER..... 457
DEWAR, JAMES. Liquid Hydrogen and Helium, 311; Various Low Temperature Researches 438
DICK, M. E. Electrolysis of a Salt 536
DISCUSSION OF QUESTIONS..... 191

E

Earth's Magnetic Field, A Simple Method of Measuring. HERMAN D. STEARNS... 527
Electrolytic Dissociation, The Theory of. LOUIS KAHLENBERG..... 395
ELLIS, GRACE F. Physiology as a Science Study in the High School..... 273
Engineer, The Preliminary Education of the. JOHN PERRY..... 265
Examination and the Examinee in Elementary Science, The. JOHN WADDELL..... 515
Experimental Illustration of Osmotic Pressure, An. C. F. ADAMS..... 522
EWING, A. L. A Falling Body Machine 168
Experiment in Resolution of Forces, An. E. C. WOODRUFF..... 523

F

Falling Body Machine, A. A. L. EWING..... 168
Feeding Habits of Fishes, The. C. JUDSON HERRICK..... 324
FOSTER, F. H. A Method of Determining the Value of Gravity..... 459

G

Ganong, W. F. Plant Physiology for the High School..... 429
Garner, Jesse H. Magnetic Phantoms..... 103
Geologist, The Training and Work of a. C. R. Van Hise..... 505
George, George. A Combined Filter Funnel and Beaker..... 343
Gray, Arthur W. Polarization of a Galvanic Cell..... 217
Gudeman, Edward. Corn or Glucose Syrups..... 22
Guthe, K. E. The Singing and Speaking Arcs..... 209

H

Hall, Edwin H. The American Physics Teacher's Opportunity..... 57
Hall, Winfield S. The Relation of Physics to Medicine..... 443
Harmon, H. W. Weather Work in the Schools..... 45
Hawkes, W. H. A Simple Method of Purifying Mercury..... 215
Hawthorne, W. C. Details of an Experiment in Composition of Forces..... 26
Heliotrope, Another. E. C. Case..... 101
Herbarium, Shall the Preparation of a, and the Identification of Species form a Part of the Required Work in our Secondary Schools? Gilbert H. Trafton 89, 148
Herrick, C. Judson. The Feeding Habits of Fishes..... 324
High School Botany. V. A. Suydam.....435, 500
History of Zoology Teaching in the Secondary Schools of the United States, The. Marion R. Brown..... 201

J

Jolly Balance, The Use of the, in Calorimetry Experiments. Harvey L. Curtis... 337

K

Kirkwood, J. E. The Cocoanut—Its Composition and Germination..... 402

L

Laboratory Material for General Biology. A. J. Grout..... 220
Laboratory Work in Physical Geography. A. C. Norris..... 520
Le May, John. A Spectrometer..... 32
Linebarger, C. E. The Determination of the Weight of a Liter of Air, 45; An Experiment Showing the Relationship Between Pressure and Boiling Point, 156; A Demonstration of Vapor Tension at Ordinary Temperature..... 105
Liquid Hydrogen and Helium. James Dewar..... 311
Low-Temperature Researches. James Dewar..... 438

M

Magnetic Phantoms. Jesse H. Garner..... 103
Manwaring, W. H. Alcohol a Food, 127; The Circulation of the Blood, 28; The Duty of the University to the Secondary School Teacher of Physiology and Hygiene, 153; Tuberculous Sputum in Public Streets..... 408
Mast, S. O. A Method of Collecting Amœbæ, 407; Formula for Aquarium Cement, 128; Plans for a Biological Laboratory..... 166
Medicine, The Relation of Physics to. Winfield S. Hall..... 443
Mercury, A Simple Method of Purifying. W. H. Hawkes..... 215
Method of Determining the Value of Gravity, A. F. H. Foster..... 459
Method in Science Teaching. Louis Murbach..... 12
METROLOGY. The Recent Metric Bill, Rufus P. Williams, 529; System in Metric Weights and Measures, 411, 464; How Uncle Sam Got a Decimal Coinage, William H. Seaman, 233; The National Bureau of Standards, Rufus P. Williams, 111, 175; Decadence of the Vulgar Fraction, Rufus P. Williams, 41; Teaching of the Metric System, Wm. F. White, 350; Action of Mechanical Engineers on the Metric System, 534; Colonial Premiers Recom-

mend the Metric System, 236; For and Against the Metric Bill, 177; The Metric Movement in Congress, 43; Literature on Weights and Measures, 298; La Convention du Metre et le Bureau Internationale des Poids et Mesures 298
Mounting for an Oscillating Mirror, A. E. C. WOODRUFF..... 94
MURBACH, LOUIS. A Simple Atomizer, 346; A Simple Auxanometer, 358; Method in Science Teaching 12
MYERS, GEORGE W. Elementary Experiments in Observational Astronomy..... .....35, 107, 169, 223, 288

N

NEWELL, LYMAN C. Notes on the Progress of Chemistry, 229; Preparation and Training of the Teacher of Chemistry, 487; Professor Remsen on the Teaching of Science 129
Nitrogen in Nitric Acid, A Simple Proof of. OLIVER P. WATTS..... 115
NORRIS, A. C. Laboratory Work in Physical Geography, 520; The Science Teacher as a Public Benefactor..... 199
NORTON, WILLIAM HARMON. The Teaching of Science..... 193
NOTES. Biology, 299, 357; Botany, 44, 179, 469; Chemistry, 114, 301, 359, 536; Geology, 45, 537; Physics, 179, 537; Physiology, 180, 414.

O

Osmotic Pressure, An Experimental Illustration of. C. F. ADAMS..... 522

P

PATTERSON, J. W. Pupin's Invention..... 279
PEPOON, H. S. An Instructive Seed Experiment..... 179
PERRY, JOHN. The Preliminary Education of the Engineer..... 264
Physical Theory, Revision of. HENRY S. CAHART..... 371
Physics Teacher's Opportunity, The American. EDWIN H. HALL..... 57
Physics Teaching, Matter and Method in. R. H. CORNISH.....327, 387
Physiology as a Science Study in the High School. GRACE F. ELLIS..... 273
Plant Physiology for the High School. W. F. GANONG..... 429
Plant Physiology in the High School. C. R. BARNES..... 320
Polarization of a Galvanic Cell. ARTHUR W. GRAY..... 217
Preparation and Training of the Teacher of Chemistry. LYMAN C. NEWELL..... 487
Pressure and Boiling Point, An Apparatus for Determining the Relation Between. N. F. SMITH..... 339
Pupin's Invention. J. W. PATTERSON..... 279

R

Remsen, Professor—on the Teaching of Science. LYMAN C. NEWELL..... 129
REPORTS OF MEETINGS. Association of the Science Teachers of Central Illinois, 55; Central Association of Physics Teachers, 242, 473; National Educational Association, Physical Science, 368; Eastern Association of Physics Teachers, 53, 425, 303; Michigan Schoolmasters' Club—Physics Conference, 186,—Biology Section, 124, 188; Natural Science Association of Ontario, 186; New England Association of Chemistry Teachers, 119, 184, 469; New York Association of Biology Teachers, 49, 185, 421, 469; New York Chemistry Teachers' Club, 118, 419; New York Physics Teachers' Club, 54, 118, 418, 540; New York State Science Teachers' Association—Biology Section, 543—Physical Science Section, 51; State Science Teachers' Association of Indiana, 242; Upper Peninsular Educational Association, 368.
Research Work, The Value of—in Education. SAMUEL J. SAUNDERS..... 1
Resolution of Forces, An Experiment in. E. C. WOODRUFF..... 523
RUNKE, RICHARD. Elements of Agriculture in the High School Course..... 282

S

SAUNDERS, SAMUEL J. The Value of Research Work in Education..... 1
Science Teaching, Method in. LOUIS MURBACH..... 12
Science Teaching Preparatory for the High School. HERBERT BROWNELL..... 251
Science, The Teaching of. WILLIAM HARMON NORTON..... 193
Science Teacher as a Public Benefactor, The. A. C. NORRIS..... 199
SEAMAN, WILLIAM H. How Uncle Sam got a Decimal Coinage.....233, 292
Secondary School Teacher of Physiology and Hygiene. The Duty of the University to the. W. H. MANWARING..... 153
SMITH, N. F. An Apparatus for Determining the Relation Between Pressure and Boiling Point..... 339
SMITH, WARREN RUFUS. Examination of Baking Powders..... 342
Snail, The European Edible. M. A. BIGELOW..... 405
SOHON, M. D. The Courses in Chemistry and Physics in the New York High Schools 419
Spectrometer, A. JOHN LEMAY..... 32
SPEYERS, C. L. Chemistry in Education.....70, 133
Standards, The National Bureau of. RUFUS P. WILLIAMS.....114, 174
STEARNS, HERMAN D. A Diagram Illustrating Uniformly Accelerated Motion, 334; A Simple Method of Measuring the Earth's Magnetic Field..... 527
SUYDAM, V. A. High School Botany.....435, 500

T

Teaching of Science, Professor Remsen on. LYMAN C. NEWELL..... 129
Telescope, A Skeleton. E. C. WOODRUFF..... 341
TRAFTON GILBERT H. Notes on the Study of Seeds, 237; Shall the Preparation of a Herbarium and the Identification of Species form a Part of the Required Work in our Secondary Schools?.....80, 148
Tuberculous Sputum in Public Streets. W. H. MANWARING..... 408

V

Value of Research Work in Education, The. SAMUEL J. SAUNDERS..... 1
Vapor Tension, A Demonstration of—at Ordinary Temperature. C. E. LINEBARGER 105
VAN HISE, C. R. The Training and Work of a Geologist..... 505
Volumetric Synthesis of Water as a Practical Quantitative Lecture Experiment, The. ERNEST F. BURCHARD..... 460

W

WADDELL, JOHN. The Examination and the Examinee in Elementary Science.. 515
WATTS, OLIVER P. A Simple Proof of Nitrogen in Nitric Acid..... 115
Weather Work in the Schools. H. W. HARMON..... 451
What of Chemistry Shall be Taught in the High School and How Shall it be Taught Most Effectively? L. M. DENNIS..... 446
WHITE, WM. F. Teaching the Metric System..... 350
WILLIAMS, RUFUS P. Decadence of the Vulgar Fraction, 41; Improved Method of Applying Test for Nitrates, 301; The National Bureau of Standards, 114, 174; The Planting of Chemistry in America, 75, 139; The Recent Metric Bill.. 529
WOODRUFF, E. C. An Apparently Safe Way to Mix Chlorine and Hydrogen, 535; Balance Details, 29; An Experiment in Resolution of Forces, 523; A Mounting for an Oscillating Mirror, 94; Record of the Disruptive Discharge of a Condenser, 179; A Skeleton Telescope, 341; A "Tumbler Galvanometer".... 341

Z

Zoology Teaching in the Secondary Schools of the United States, The History of. MARION R. BROWN.....201, 256

School Science

VOL. II] MARCH, 1902. [No. 1

THE VALUE OF RESEARCH WORK IN EDUCATION.*

BY SAMUEL J. SAUNDERS.
Professor of Physics, Hamilton College, Clinton, N. Y.

We often hear the opinion expressed that the modern methods of education do not produce as good results as the old-fashioned ones. Is this true, or is it but the croak of the pessimist? Be that as it may, the questions and discussions at such gatherings as this make it evident that our modern methods are not yet entirely satisfactory. Is the fault in the choice of subjects, or is it in the teachers and their training? What do we mean by good results? What do we ask our teachers to do for us, and for our rising generation? These questions seem to bring us to a consideration of the best methods of education.

The test of every educational system is the product which it forms. It should produce men who think and decide for themselves, men of action, who make their mark in the world, who succeed in whatever they undertake, whether the problem be scientific or social. It should make of the average man an intelligent, clear-thinking, truth-loving and cultured citizen. The object of education is to expand and train the mental faculties, to teach people how to think for themselves, and that discipline is the most valuable which makes us the most self-reliant, and enables us to make the best use of our reason and judgment with respect to all matters pertaining to our own welfare and that of the community.

In that delightful book, "Helen's Babies," the author strikes a chord which finds a response in every human breast, when he

*Abstract of an address delivered before the New York State Science Teachers' Association at Syracuse, Dec. 27, 1901.

[illegible]

[illegible]

[illegible]

testing the correctness of this conception by repeated observations and modifying it as experience widens.

As we grow older and are able to understand the answers and explanations of others, our power of applying the research method seems to fall off rapidly. The ease with which we can then obtain information by asking questions, does away with the necessity for much mental effort on our part, and we gradually cease to investigate for ourselves, this power dying away with disuse like any other power. Moreover, we fall into the habit of appealing to, and relying upon, authority. The child should be placed under such conditions that his desire for the acquisition of knowledge can be kept alive and fostered, and so that he does not lose the habit of systematically searching for truth by the aid of known truths, and testing the validity of each step by constant reference to experience and experiment.

It is important that this power of applying the research method, this acquiring of science-forming ideas, should be raised to as high a pitch of efficiency as possible before we stand face to face with the problems of life. It becomes more and more difficult to begin to apply this method as we advance in years. It is unwise, then, to postpone its cultivation until we have entered upon the special duties of our life-work. It should be cultivated, as we have said, during the whole school career, from the kindergarten up.

Much of our modern education fails because many subjects, even the sciences, are learned as the dates of important events in history are learned; the memory alone is exercised; reason and judgment do not come into operation, unless it be merely to refer matters to some authority which is considered final. It fails, too, because the pupil is not trained to apply his knowledge. It is by constantly making practical use of the knowledge we possess that the power of original application of knowledge is best brought out. The pupil should test his knowledge continuously, and learn "to do by doing." In language study he should translate from one language to the other, until he has acquired readiness and facility in the process; in mathematics he must work problems, and in the sciences he must prove his theories by experiment. He

should use his knowledge and reasoning with respect to some phenomenon, and then test his ideas by experiment. The result usually shows him that his preconceived opinions must be modified, or perhaps wholly abandoned; that there are laws which must be discovered by patient labor and investigation. He realizes also, that he must be constantly on his guard against errors, that he must become acquainted with the sources of these errors and learn to fulfill the conditions necessary to avoid them. He may be able to learn a great deal about the truths and principles of science, and their experimental illustrations, by reading about them in a good text book; he learns more, if, in addition to the reading, he can see the experimental illustrations and demonstrations performed by another; but he learns most and best by doing them for himself. There is nothing that brings the truth home to the mind so well as experimental proofs carefully carried out for one's self. The possession of knowledge does not confer upon a man the ability to use it, and the possession is of no value if it cannot be used and applied. If our one talent is to gain other ten talents, it must not be buried in the earth.

That knowledge which we have acquired by serious thinking and hard work we are apt to value and remember; it becomes, at least, a more secure possession than that which has been easily and lazily gathered while enjoying a cigar and fan. The difficulty of a book, or subject, is not in itself an objection to its use in education, for to learn how to overcome difficulties is a very valuable part of the training. Mathematics are hard, and Greek is hard, and that is one of the reasons why they are such excellent educational subjects. In the present day, however, when there is so much to learn, we are always on the look-out for the "Royal Road," and even when we have done our best to smooth the way, there is considerable difficulty left.

Our modern system of education should stand out against the abuse of authority and memory. The lack of time, and the necessity of mastering a certain amount of information in which examinations have to be passed, are perhaps the main causes of these abuses. Examinations, as they are usually given, test only the memory, not the powers of reasoning and judgment.

Culture does not depend so much upon the subjects, as upon the method and persistence with which they are pursued. It is no argument against the study of the classics, that the proper study of science makes keen thinkers and able men, for the classics properly pursued will do the same; nor, on the other hand, is it any argument against the sciences that the classics have produced the profound thinkers and eminent scholars of the past. Who will ever know how many thousands there were, during the past centuries, who had no love for the study of classics or mathematics, and who had no opportunity to test the educative power of other studies?

It is estimated that about two per cent of all boys are clever, and for a clever boy any subject of study is good enough, one perhaps as good as another, if it enables him to come into close mental contact with great thinkers. But what about work for the other ninety-eight per cent, the average boys and the dull boys? The study of the sciences proves to be the intellectual salvation of many of these. It arouses some minds which nothing else seems to reach, and it develops and trains, in all cases, faculties which otherwise would have remained dormant.

Progress is always greater when the work is pleasant, and there are so many ways of study offered by the sciences that one has a chance to select that which is most attractive for him, and instruction from the teacher need not change or hinder his own natural method of study. Some branches are almost purely observational; but, if he prefers abstract reasoning, he takes up the mathematical side; or, if he loves to make apparatus and use it, he approaches the subject on the experimental side.

A two-fold advantage is claimed by the advocates of science studies; first, that they are a means of the best mental training, and, secondly, that they communicate a kind of knowledge which is of practical use in everyday life. It has been said that the teaching which limits the range of a man's vision to the subjects and facts of which he can see the use does not deserve the name of education, the very essence of which is the strengthening of the intellect by mental exercise. But in these days of fierce competition in the industrial world, we must study more and more those truths and

principles of abstract science which lie nearest the useful. There are many problems in nature the solution of which would confer great material benefits upon mankind in general, and in which the processes and methods involved in carrying them to a successful conclusion are identical with those which the problems of pure science require, while the discipline and training imparted are equally good. I am not encouraging the idea that utilitarianism should be made the end and aim of education; but what is the advantage of, for instance, making a close study of the planet Mars, its markings, its climate and its physical conditions, when we know little or nothing of the composition of the earth's crust, or of water, or air, or the glass in our windows, or what the nature of the light is that shines through them? The widest culture is the noblest culture; universality and thoroughness may go together, but why do we so often go far afield for subjects for investigation and study, when there is much that is just as good near at hand, and perhaps more likely to prove useful in everyday life?

There is a kind of knowledge that is actually becoming a necessity. It is that knowledge which best unlocks nature's storehouse, and enables us to wrest from her more than has ever been obtained before, that knowledge which will enable us to find out and use powers of nature which have never been used before. The great success of Germany in commerce and manufactures is due to the particular attention paid to the physical sciences. Sooner or later knowledge and method and industry must tell. Dr. Lockyer, the English astronomer, said, recently, in an address: "I look upon scientific education as a great and necessary line of defense for our country, perhaps scarcely secondary to our naval and military forces."

The connection between scientific and technical education is a close one. In the laboratories new discoveries are constantly being made, science makes known to us new properties and qualities of matter, and mechanical invention applies these discoveries to industrial processes. A thorough training in abstract science is a necessary groundwork for a technical education, for how can one understand the practical applications of a science unless he is familiar with the underlying principles of that science? To spe-

cialize without the proper preparation is like building the top story of a house first, when it is completed you have but a one-story house, and it sits on the ground.

The applied science of the future is now in the process of formation in the operations of those who are working in pure chemistry and physics. Thousands of investigators are patiently working in the laboratories in all parts of the world to bring out new knowledge, and each year now witnesses more discoveries than a century used to. A renowned painter was once asked which he regarded as his greatest painting; he answered "The one I am about to paint." The greatest discovery in science is "The one that is about to be made." The best teaching inspires the student with the conviction that he also can work out new truths, and make some permanent additions to human knowledge.

A scientific man, as such, is valuable according to the amount of new knowledge he is able to bring out, or if he is not engaged directly in research, according to the number and ability of the workers which he prepares and equips for the bringing out of new knowledge. We lead in the struggle for commercial supremacy among the nations of the world, partly because of our great natural resources, but largely because we have such a good supply of investigators and well-trained managers, and workmen competent to take instant advantage of every discovery in science. We must maintain, or even increase, the number and efficiency of such men, and must afford them the facilities for acquiring the necessary scientific knowledge and training. The investigators and managers, perhaps, receive their training in the universities or technical schools, but the workmen, who should be sufficiently well-trained to take the initiative whenever necessary, must depend entirely upon what they receive in the public and high schools. If in these schools they are taught to understand and apply the best-known general principles they will be able later to master a given set of practical details with readiness and facility. To the science teacher, then, belongs in a large measure, the task of preparing all these, so far as education is concerned, for their work in life. Every teacher who teaches science thoroughly is training skilled teachers for the rising generation. He should have, not only a thorough

knowledge of his subject, but the ability to impart that knowledge to others, and the willingness to do his utmost.

It is, of course, indispensably necessary that he should be well grounded in his work, and should have a thorough comprehension of the methods and principles of his branch of science, but there is, for the teacher, even though a specialist, a great value in general culture. The man of broad culture and refinement seems to impress his ideas upon the pupil's mind in a way that makes them stick. The teacher who knows his special subject well, but not much in other lines has difficulty in doing this. The two-fold caution so often given by Bacon against over-generalization on the one hand, and against over-specialization on the other, is still as deserving as ever of the attention of mankind.

A recent writer says that science is ever seeking to write in pure symbols, hence it is not comparable with what we understand by literary work. Some of the grandest truths may be presented to the mind by means of pure symbols.

There are truths which cannot well be expressed in any other way. It is said that Newton, after waiting for years to secure accurate data, was so overpowered by emotion, as he neared the end of his calculations, that he was unable to finish them, but called another to do so for him. Yet what Newton saw was a few pure symbols, a simple arithmetical expression. But that simple expression revealed to him the fact that every particle of matter attracts and is attracted by every other in the universe. He was thrilled by emotions which language is powerless to express or describe. Have you ever gazed upon a scene of such grandeur and magnificence that you realized that language was perfectly inadequate, that you could not even attempt a description of your feelings? Then you may understand what he felt.

Speaking now more especially concerning the value of research work proper, we might consider first, the perceptive faculties. One of the first things the student in scientific research must do, is to learn to use his eyes. He must be an accurate observer of the various objects and phenomena with which he is concerned. A great deal of our knowledge, if we are to profit by the labors of others in the same field, must come from books, but we should

insist that the learner be taught to observe for himself before he appeals to the experience of others. The ancients seem to have been particularly deficient in the power of observing. They gave much attention to astronomy but they record the number of fixed stars visible to the naked eye as 1600, while we now give the number as nearly 4000. We also give about 20 as the number of nebulae and star-clusters visible in our latitudes, while Hipparchus gives two and Ptolemy but five, both of them omitting such remarkable objects as the nebulae in Orion and Andromeda. The constellation of the Pleiades was considered of great importance for navigation and was constantly observed, and yet only seven of its stars were discovered. In fact the seventh one was lost sight of for centuries, and ultimately when the middle star in the tail of the Great Bear first attracted attention, the conclusion arrived at was that it was the missing 7th star of the Pleiades. Nowadays cases are known of people who are not astronomers seeing from 14 to 16 stars in the Pleiades, and it is by no means uncommon for people of good sight to see 11. The star Alpha Capricornus was seen by man for thousands of years without it being noted that it was a double, a fact that any child would discover now, if its attention were directed to the star. It would be interesting to know in how far we inherit a trained eye from generations of ancestors who gradually accustomed themselves to the accurate observation of objects. In addition to training his perceptive faculties, the student in research must exercise his reasoning powers to work out and understand his observations, and systematize them, and compare them with others. In science we are much more concerned with the quantitative relations than with the qualitative, and as our knowledge increases that part of it which is mathematical also increases and becomes in many cases quite difficult. In planning and conducting operations in research work there is abundant opportunity for the development of the constructive imagination, originality of mind, and inventiveness. He must change his apparatus and appliances to meet the requirements of the problem in hand, or perhaps devise and construct new pieces as he amends his processes. Patient industry and self-denial, which are the first conditions of scientific investigations,

develop self-reliance, and impart strength and solidity to character. With what wonderful patience and perseverance did Kepler work! For 22 years he read the face of the star-lit heavens, tracing and measuring with patient exactness the positions and paths of his celestial wanderers, before he was able to deduce from his results the laws of their motion. Every notable scientific achievement rests upon a long-continued series of patient observations.

Research work calls into active play the powers of the imagination. A noted critic has said that the two men whose imaginations were the most brilliant of any of their day were Michael Faraday and Charles Darwin. All the phenomena with which the scientific investigator deals are concerned with the actions of the invisible and unseen upon the visible. There is force, energy, electricity, the universal ether, and many other such subjects or conceptions to consider and explain or describe, and the imagination is often unequal to the tasks imposed upon it.

A French Bishop, who had become greatly troubled over the nebular hypothesis, or the six literal days of Genesis, or something of that sort, preached a sermon in which he inveighed fiercely against science and scientific men, with a repetition of that condemnatory vigor which landed Galileo in prison. At the close of the service a noted astronomer went up to him and said "Monseigneur, have you never seen God?" "No," said the surprised Bishop, "I never have." "Then, your Grace, I have," was the reply. "I have seen Him in the great cathedral of the universe, I have felt Him in the movements of creation, I have witnessed His workings from nebula to star and from star to planet, I have read those Scriptures of the sky which you have not, I have touched His robe and know Him as a visible being."

In research work our ideas are of value only so far as they are true. Perfect frankness and truthfulness of mind are indispensable to success. Each new problem must be approached with the mind open for the reception of new truth, and all preconceived opinions must be laid aside or held subject to revision. It often requires the utmost skill and attention to sift the truth from the error. One must be careful and accurate both in measurements and statements. Extreme accuracy often leads to valuable discov-

eries. The discovery of the aberration of light would not have been made if Bradley had not been able to measure accurately to 1-100 per cent. To the fact that Rayleigh was not content to allow the small discrepancy of 1 part of 10,000 to pass unnoticed, the discovery of Argon is due.

Scientific investigation trains in mechanical operations, in manual dexterity and manipulative skill. There is constant adjusting and handling of apparatus, and many operations which are apparently easy, require a deftness and accuracy of touch which comes only from practice. Research work strengthens the memory, for the investigator must remember a large number of facts, and their mutual relations. It brings home to the mind of the investigator the fact that he must stand entirely upon his own merits. Credentials, certificates and diplomas avail him nothing. He realizes that they are no more than the stamp upon a coin, which makes it a counterfeit, unless the metal itself be genuine. Lastly, research is one of the most vital factors in the promotion of civilization, one of the most powerful levers of national prosperity and influence. Time will not allow, if, indeed it were necessary, to call attention to the wonderful discoveries of even the past decade. And yet how many of us think of the latest discovery as if it were really the very last that can be made. Research will never proclaim any proud period and her work accomplished, it grows from more to more. The good ship "Discovery" is well under way and the ocean of triumphant progress in unbounded.

METHOD IN SCIENCE TEACHING.*

BY LOUIS MURBACH,
Department of Biology, Detroit Central High School.

A man's power depends on three things; his native ability, his environment, and his education. It is only the latter that can enter into a discussion on method.

Much has been said about what education is, but of all its alleged components I regard two as adequate,—informing and training. Education begins with the first of these almost solely, being, later, supplemented by the second. The child's earliest acquirements are impressions and these become information stored in the mind, to be followed by the discipline of later school years and experience in life. This, too, has been the natural method in the growth of education.

The humanities being the earliest knowledge possessed by man, naturally formed the first material for an education and were simply acquired and handed down, exercising chiefly the memory and requiring little effort except attention on the part of the recipient. There was little exercise of thought, little comparison, judgment, or conclusion. Even the faculties of attention and retention were pampered by repetition, this feature giving rise to the Jesuit maxim, *"Repetitio est mater studiorum."*

When progress enough had been made in science to win for it recognition as one of the elements of an education, it was imparted by the method employed in the teaching of the humanities, and there was no distinctive method in science teaching. The deductive sciences, philosophy and mathematics, were the earliest taught and continued to employ largely the same method for a long time after experimental or inductive science became independent enough to break away and use its own method.

A part of the real value of the laboratory method—observation at first hand—is gaining knowledge by experimentation; and this is the practical application of the syllogism of philosophy which has been the classical method of mind training. The labora-

*Condensed from a paper read before the Detroit Principals' Association, April, 1901.

tory method has given us this most efficient way of learning facts of science, making them a part of our knowledge instead of parroted wisdom. But experiments teach not only facts and principles; they also train, and give power to find new data and laws, and so contribute to human knowledge.

Not only the mind, but the avenues of the mind must be trained. Manipulation, observation, reflection, comparison, judgment,—all must be exercised. Because the student *himself made the experiments and observations* in specially fitted rooms, called laboratories, instead of *being told about them* in lecture halls, this method of natural science study came to be called the laboratory method. Its first introduction into schools was in connection with biology, and in England, Huxley, and in this country, the elder Agassiz, were its champions, to whom it owes much.

Theoretically this method is the re-investigation of causes, facts, principles or laws that underlie natural phenomena, but re-investigated under instruction and guidance, the most favorable circumstances that can be imagined. So the process is a stimulating one, if the material is adapted to the age of the student in such a way that his powers are constantly exercised but not overtaxed. For early education it has the advantage of proceeding from the concrete to the abstract, from the simple to the complex, from the known to the unknown—following the order of the developing mind.

Practically it has been much abused by instructions and directions given in such a way that the student becomes a mere verifier,—an intellectual drone,—asking "What is to be seen?" and "What conclusion is to be drawn?", instead of being encouraged to a much needed independence.[2] There are at present several idealists: Those who tell nothing; those who direct the student in such a way that he can independently find the important data; those who tell all. The last are usually the old school scientists who hold, for instance, that the student must first learn the laws of gravitation before he experiments with falling bodies. They object that there is not time for rediscovering principles or laws that scientists have spent a long time in understanding. But we

(2) Dr. W. F. Ganong's Laboratory Course in Plant Physiology, 1901, of which notice was given in the November No. of SCHOOL SCIENCE, is a model book in this respect.

answer, that the man who discovers something, in order to do so, must have had more power than his fellows and he has developed this power along his line of discovery by slow increments. May not the student, by this very method, gain a power which will carry him far in advance of the point he would have reached by the old didactic method of science work? It is not so hard now-a-days to get an affirmative answer, since it is generally conceded that even in secondary schools discipline is more important than the amount of knowledge stored. The latter may be forgotten or misapplied, but the former gives power to reproduce forgotten facts or to find new ones. But before giving power, laboratory work begets a habit of thoughtful and accurate observation, careful consideration of all phenomena or facts—a most important preliminary step in all education.

Now, while it was said no more time need be given for finding facts and rediscovering principles than required for another lesson, this means a lesson of equal value. It is important in the laboratory method to give time enough for each experiment to understand fully the factors included, separating those not touching upon the question from those involved in its decision. The next step in the process is the comparison of facts observed, or the results of an experiment with those of another experiment or with some experience. All this is necessary before the final step, the drawing of the conclusion. Here we see a striking difference between this and the informational method. In the latter nothing further is required than to receive, and apply (?) that which is received. And when students in our schools learn to acquire things by the laboratory method they are doing what advanced scholars used to do, and in so far our present system is ahead of the old. Is it surprising that students have to be urged to compare related facts and draw conclusions when it is adult nature to follow prejudice rather than facts and their consequences?

Going a little more into detail of the method in natural science teaching, we may say it is the easiest one to follow. In the first place, it is the observation and comparison of the evident phenomena in nature, and this is akin to analysis. Thus to learn the use of fleshy fruits, these are examined, and it is observed that

all fleshy fruits have some food material, bright colors and agreeable odors and flavors, which can be of no direct use to the seeds they contain. These have nearly the opposite qualities. Now, when it is asked what will happen if an animal, attracted by these inducements, carries away and eats the fruit, the inference (synthesis) that the seeds because of their qualities are rejected and thus scattered, leads to the larger truth that fleshy fruits are solely for the distribution of seeds. This general method of observation of things themselves, comparison and inference, has been found so valuable that it is no longer employed in science alone, but also in other studies, being used to some extent even in language teaching. While the observational method in general has been applied to other studies, the experimental method can be used in science alone.

Since not all of nature's processes are open for inspection of cause and result, a large number of phenomena must be determined by what is known as the method of experiment,—that is by modifying the natural conditions in such a way as to get definite or special results, and from these artificial conditions to obtain facts or data from which the natural processes can be inferred. As the experiment is so important both in science and in science teaching, and has been so much perverted, it may be well to go more into detail on this part of the subject.

Some one has said "An experiment is a question put to nature." Another view is, that an experiment modifies the conditions of nature in such a way as to show what are the natural phenomena. This seems to me more comprehensive.

I believe it is the consensus of opinion that an experiment is a test or trial to find out something; and since it is to reach some conclusion it is in the nature of a syllogism and must embody two premises. If this is true, a moment's reflection will show that a great many so-called experiments in our text books are merely illustrative or confirmatory. This is always the case where the proposition is stated first, or where the object of the experiment foretells the conclusion. Such experiments might as well add the *"quod erat demonstrandum"* of our geometries.

In order to determine any point by an experiment we must

have two sets of facts, one of which may be the conclusion of a previously performed experiment. Thus if the learner is to test unknown substances for starch he must apply iodine, not only to the substance, but also to some known starch. In the student's training it is very important that this step be taken; simple though it seems, it is fundamental for inculcating accuracy. After the experiment has been observed a sufficient length of time we have two distinct results, and by an act of comparison and judgment from these two, the thing to be found out, or conclusion, is drawn. Accordingly, the chief points of an experiment are conditions, results, and conclusion.

It is the experience of nearly every teacher that the pupil remembers the apparatus better than he does the essentials of an experiment, better, even, than the conclusion. Having learned by experience that the apparatus impresses itself on the pupil's mind to the detriment of the real principle, the teacher would better have him describe only the conditions as brought about by apparatus, operation, or any modification of natural conditions. This has another advantage; it does away with the necessity of describing the object of the experiment, in which operation, very frequently, the conclusion is too nearly hinted at, and the pupil becomes a verifier instead of an independent observer.[3]

Another great difficulty is in getting the student to see clearly the difference between the results of the modified conditions and the conclusion that can be drawn from such results. He often states the conclusion and gives it as a reason for the result or he cannot get any conclusion at all. Frequently this is because the experiment takes into account experiences that the student has not had. On the whole, it is a lack of perception of the relation between cause and effect and is a part of the student's training that needs serious attention.

All this can be remedied by patient questioning, shifting premises, etc., but a better way, I believe, is to give some simple experiments leading up to the one in question, or, it may be, several different experiments leading to some of the most important

(3) Out of many high-school textbooks on science that I have seen only two are practically free from this fault of "giving away" the conclusions of experiments.

principles to be fixed. There is another value in giving more than one experiment, and that is, more perfectly clinching the fact or principle taught, to say nothing of the discipline. It will lessen the tendency of placing the apparatus in the foreground, since the final result is obtained with different apparatus. It will also do away with the temptation to make experiments easy by prefacing them with, "to show so and so," in which case most students, even when the experiment fails, will draw the prefixed conclusion. This is pernicious, as it changes the experiment into a mere illustration, warps, by its insinuation, the pupil's too plastic judgment, and lessens his independence.[4]

The making of several experiments for one conclusion also recognizes the time element in education. To grasp any idea well, the young mind, especially, must have time in proportion to the difficulty of the idea; but the time is not profitably put in if the idea is beyond the experience of the pupil. Here, again, there is danger that the pupil will be carried along by the teacher instead of being allowed to pick his own way. To do this independently a few simpler experiments can be given as preliminaries, leading up to the principal one. To illustrate: a test for oil in seeds should be preceded by an experiment on a seed known to contain oil; the experiment for starch-making in leaves should be preceded by the test for starch, then by an experiment for starch in a normal leaf, then by one on an etiolated leaf.

Naturally the lack of school time for this method will be the overwhelming objection urged by all. But since this kind of training and the knowledge gained is so fundamental, the old adage of "a stitch in time" was never truer than the assertion that right here the pupil's whole intellectual future is at stake. He would better take time at first to save it at the last.

The application of the science method in primary schools might begin with nature study in the grades, and for this it would be best if we did not study any special science but some part of nature as a whole. It would be most profitable if the study were largely observational, few inferences being drawn until many data

(4) Professor N. A. Harvey (SCHOOL SCIENCE, Vol. 1, No. 3, p. 121) records similar experiences.

are at hand. The observations may be along the line of experiences rather than experiments, at first; thus, instead of making experiments, as is done in the high school, for determining the conditions necessary for the germination of seeds, let the pupil simply place seeds in favorable conditions and watch them germinate and grow, thus realizing that they are alive and can do something.

External general observations as to form and parts are simple and easily made and may lead to simple inferences.

In the higher grades general relationships and some classification of phenomena would give a bird's-eye view and prepare for the studies following.

Some of the easier parts of physical geography might be taught in the eighth grade. This should be followed by the more difficult parts of the same study in the ninth grade, by botany, zoölogy and physiology in the tenth grade, by two courses of chemistry in the eleventh grade, and two courses of physics in the twelfth.

It is not an infrequent complaint that the work in science does not show for as much as that in the languages or mathematics. Is this to be wondered at when the pupil begins the latter studies with his entrance into school and continues them through his whole course, while he may have anywhere from but one to three terms in science? And his science teacher frequently has this as an adjunct to several other studies. How can such a teacher be expected to practice any particular method or make any strong impression on his pupils?

To give natural science studies and their method of educating a fair chance would mean consecutive and logical arrangement of things studied from the first grade up; continuousness or sequence to be followed out through the whole school course even if only a small amount of time be given daily.

BIOLOGY IN AMERICAN COLLEGES—ITS METHODS AND OBJECTS.

BY FRANKLIN W. BARROWS.

A few months ago, the writer addressed a series of questions on biology to half of the colleges and universities of the United States, selecting those having the most complete equipment. Nearly one hundred replies were received, representing the largest and best known universities as well as some of the smallest and most obscure colleges. Although these one hundred institutions are only a quarter of all our schools devoted to the higher learning, yet, for the purposes of this inquiry, they may fairly be called representative, because they constitute fully half of all the institutions in which the biologic sciences receive any special attention.

It is because a hundred college and university professors here speak of and for themselves, that this medley seems worth printing. Many of the replies are quoted verbatim. Others are summarized in the discussions following each question.

Question 1.—What feature of biological study do you try to emphasize in your institution?

"Fungi and insects as related to plant diseases."

"First—Accurate morphological work. Second—Study of theories, critical, analytic and synthetic."

"I give a laboratory demonstration of every principle taught in class. I am emphasizing personal contact with nature."

"The study of the phylogenetic development of the animal kingdom as culminating in man, and the parallelism of man's ontogenesis."

"The practical knowledge of vital phenomena from the zoölogical side."

"We give more attention to structure than to classification."

"Anatomy, morphology, and taxonomy of plants."

"1. Function. The work of species—interrelations. 2. Physiology. 3. Neurology. I am strongly on the side of activities, functions, etc., because therein lie most of the larger human values; and, where this point of view is not held, the work has little solid quality. It needs the human interest to put common sense into it, and the idea of change as activity goes through its various phases to make results really logically consistent."

"For our first year's work we look at forms from the standpoint of their relation to the outside world. Laboratory work is emphasized."

"(a) General significance to educated men. (b) Importance of research."

"1. In the undergraduate courses in general, biology as a culture study in the training for the broad problems of life and the duties of life. 2. Specifically, in the advanced courses, comparative neurology is emphasized (anatomy and physiology)."

"We try to bring out the educational value of biology as a factor in a liberal college course and at the same time give the student a foundation for more advanced work."

"General study of types, preparatory to advanced work in zoölogy and palaeontology."

"Comparative morphology and general physiology."

"Laboratory work. I try to teach the students to attain a certain technical skill in doing delicate work. My students intend to study medicine, and human morphology is constantly brought before them."

"Contact with things, study of types, and then extensive reading from good library."

"Principles of comparative morphology and embryology."

"Ecological and physiological—(natural history.)"

"A thorough grounding in the *elements* of the work."

"The morphological side."

"1. Its disciplinary and informational value for students who will later study medicine or who will teach science. 2. Its general cultural value for other classes of students."

"I endeavor to train students to study for the sake of finding out."

"Relation of insects to agriculture."

"Assuming that you refer to *educational feature*, the zoölogical department lays stress on its peculiar disciplinary value. Along research lines we are developing experimental zoölogy and fresh water biology."

"Cytology and histogenesis in both botany and zoölogy."

"The study of living animals and plants."

"Physiology, in a broad sense."

"Considerable time is given to morphology, but physiology is the side we emphasize."

"Animal morphology."

"The acquisition of knowledge at first hand, for the student; a critical comparison of his own results with those of his predecessors in the same field, for the investigator."

"The morphological feature in zoölogy."

"Zoölogy is unfortunately unduly emphasized, simply because the professor is a zoölogist. Comparative anatomy or morphology receive most attention."

"The anatomy of mammals and the origin and relationship of the various groups of vertebrates."

"Ours being an agricultural state we emphasize the economic in zoölogy and entomology, but give as much of the purely scientific as possible."

"Broad scientific culture without 'features'."

"Botany, entomology."

"(1) General biology as the introduction to fundamental physiological principles. (2) Zoology."

"Botany and invertebrate zoölogy."

"The morphological side of both botany and zoölogy is emphasized at present. Embryology is prominent, also neurology."

"Biology as it finds practical application in bettering humanity. The morphological and physiological."

"Morphology of animals."

"Applications to agriculture in agricultural college. To medicine, for students preparing for medical college, and in all work the actual study of typical forms in field or laboratory."

"Morphology is perhaps emphasized; try to round out the corners as far as possible rather than to specialize."

"Comparative morphology and general physiology."

"Such biology as has been taught here has been of the old-style-text-book variety, and little or no laboratory work has been attempted. The students have been given some opportunity to prepare microscopic slides, but I cannot learn that they ever studied them."

"One man can do little if he spreads over the whole field of biology. I am trying to do something in botany."

More than 25 per cent of the institutions reporting teach all the biologic group of sciences, emphasizing nothing. It is noteworthy, however, that some of the leading universities did not hesitate to report one or more "specialties," while most of the small colleges made no pretence of covering the whole field. The branches most emphasized are: Animal morphology, 25 per cent; botany, 17 per cent; general biology, 15 per cent; physiology, 15 per cent; zoölogy, 11 per cent; embryology, 7 per cent. One tenth of the colleges pay special attention to preparation for medical courses. Two colleges aim at preparing the student to teach, and one prepares for agriculture. Three schools specialize in ecology, four in entomology, two in neurology, one in vegetable pathology, one in "phylogeny," and one in the study and comparison of the various biologic theories. The marine fauna of the Pacific receives special emphasis in one university, the biologic survey of lakes and caves, in another, while a great technical school offers special opportunities in sanitary and industrial biology. Finally, five colleges and technical schools out of the whole have either no biology at all, or no more than the average high school.

(*To be continued.*)

CORN OR GLUCOSE SYRUPS.

BY EDWARD GUDEMAN.
Chemist and Chemical Engineer, Chicago.

Corn or glucose syrups are mixtures of sugar syrups with glucose. The different grades are made by varying the proportions of sugar syrup and glucose. The color and taste of the mixed syrup depends on the color, taste and amount of the sugar syrup used, as glucose is water white and has no characteristic taste, except being sweet. Beet sugar syrup is not used straight to any appreciable extent, on account of its peculiar bitter taste, which cannot be fully hidden by the use of flavors. When used it is only to replace part of the cane sugar syrup and in the lowest and cheapest grades of corn syrups. Refineries working up cane and beet sugars, turn out low grade syrups. The quality of the sugar syrup depends on its taste and contents of actual sugar. The proportions used vary from 5 per cent to 50 per cent. To get special color or taste, sometimes as high as five different kinds of sugar syrups are used to prepare the mixed syrup. Sorghum syrups are mixtures of straight sorghum syrup, cane syrup and glucose. Most of the molasses contains glucose, although quite an amount of the straight goods are found on the market. Straight molasses is the cane sugar syrup direct from the plantation, without having been purified or refined. As molasses is very often bleached, it must be examined for mineral salts, especially zinc and tin, and if found to contain any, it should be rejected as unwholesome. Molasses bleaches very easily, and the best test is to bleach a sample, and if it does not react strongly and quickly, it can be suspected that it has been previously bleached. Maple syrups should be the straight concentrated sap from the maple. The use of glucose to make maple syrups is a very common practice, and if used in small quantities cannot be detected by the chemist. Pure maple syrups can contain up to 25 per cent of reducing sugars. A good flavored maple syrup can be mixed with 10 to 15 per cent of glucose and 10 to 15 per cent of dissolved cane sugar and not be distinguished from

the pure article. Syrups flavored with bark extracts and with maple flavors are in the market, to a very limited amount, but will never be mistaken for the genuine maple syrups. There is no question as to the wholesomeness of straight corn syrups. The addition of glucose to the raw sugar syrups materially improves them and makes them palatable, while in the impure state they would not be fit to be used as a food article. As regards pure glucose, there is now only one opinion, and that is that it is fully as healthy and as nourishing as cane sugar and much more easily digested. Sugar is changed into glucose by the action of the saliva and the stomach juices, and when so changed does not materially differ in its character and actions from the pure commercial glucose.

Not all table syrups are straight mixtures of sugar syrups with glucose. They contain various substances, some unwholesome. The most commonly used ingredients in table syrups are: Saccharine, natural and artificial flavors, caramel (phosphoric, muriatic, sulphuric or citric acid), antiseptics, especially bisulphites of soda or lime, vanilline and cumarine. A careful examination of the literature pertaining to these substances show that the ones that can be considered as directly injurious are the acids, the antiseptics and saccharine.

The manufacture of saccharine or its importation, except for medicinal purposes is prohibited by Germany, France, Belgium, Austria-Hungary, Switzerland, Italy, Portugal, Brazil and Spain. Some of these countries allow its manufacture for exportation.

Sulphurous acid and its salts are absolutely prohibited in Germany and Switzerland, and very strong restrictions placed on their use in food products by Russia and England. All substances that have strong antiseptic properties will continue to assert these properties after being taken into the stomach and must naturally retard the natural functions of digestion. The use of the artificial flavors or essences is a very bad thing, and it is to be deplored that they are so extensively used in syrups, jellies, candies, ice cream and carbonated waters. I have not been able to find any direct references against the use of such flavors and essences, and base my view on their composition. They are concoctions of ox-

ides and ethers of acetic, amylic, valerianic, butyric, oenantic, benzoic, salicylic, formic, tartaric, citric, lactic, and malic acids; others contain spirits of nitre, ether, chloroform, glycerine, fusel-oil and various alcohols. The chief constituents are amyl acetate, fusel-oil, glycerine, alcohol and some coloring matters. As all of these substances have strong medicinal properties, they can be considered as injurious in food products.

The composition of two flavors gives a good idea of the whole class.

Nectarine.—The pure flavor should be an alcoholic mixture of raspberry extract and vanilla. Analysis of the commercial article showed spirits of nitre, amyl acetate, glycerine and saccharine. 3.2 per cent. of solids, 0.03 per cent. of mineral ash, and about 70 per cent of alcohol. The price was $6.00 per gallon.

Chocolate Flavor.—The pure flavor should be an alcoholic extract of the cocoa bean. Samples examined contained no cocoa extract, but contained glycerine, ethers, and caramel. Total extract, 4.2 per cent.; ash, 0.22 per cent.; alcohol, 60 per cent. Selling price, $9.00 per gallon.

The price is no criterion of the quality of the flavor, as it is possible to make and sell a pure flavor at a few cents above the value of the alcohol which it contains. In two cases wood alcohol was used, and such flavors I consider as downright poisons.

Vanillin and cumarin I do not place into the same class with the artificial and imitation flavors. These synthetic products seem to be identical with the aromatic principles extracted from the tonka and vanilla beans. No statements have been found showing that these two flavors are in any way to be considered as injurious when used in food products. Vanilla is adulterated with acetanilide. Its purity can be quickly determined by taking the melting point. Cumarin is very seldom used as a straight flavor. It is added in small quantities to the vanillin flavor, it being claimed that this brings out the flavor of the vanillin; I have not found this to be the case. The addition of cumarin brings up the percentage of extract at low cost as compared with vanillin. Very little, if any, pure vanilla bean extract is in the market today.

This statement is liable not to be accepted, especially by manufacturers, but it is an actual fact that the vanilla extract at a cost of $4 to $5 per gallon contains 2 to 3 times the amount of vanillin as found in such extracts 10 years ago. The cost of alcohol has increased and the cost of the raw bean has not materially changed in cost or contents of extract, so the increase of vanillin must be accounted for by the direct addition of the same to the bean extract. Vanillin flavor is the most extensively used flavor of all and I believe that fully one-half of the flavored syrups contain it.

Caramel or sugar colorings are perfectly harmless if made without sulphuric acid. Some very low grade syrups consist of 98 per cent. glucose and 2 per cent. caramel. Such syrups differ from pure glucose only in color and have no characteristic taste.

China clay is mixed with syrups with the purpose of creating the false impression that the syrup contains a large amount of sugar, the cloudiness due to the sugar being imitated with clay. The use of China clay or other inert body to create such an impression is a plain case of fraud and deception. The quantity used is small as one part of clay to 600 parts of syrup gives a very distinct cloud.

Acids are added to syrups to give a peculiar tart taste, especially for sorghum syrups and molasses mixtures. No doubt the use of muriatic and sulphuric acids should be prohibited. Whether the same applies to phosphoric acid, it is hard to say. It is very extensively used, especially with carbonated waters, and I have found no direct mention of any injurious effects. Preservatives are absolutely not necessary to protect syrups against fermentation. They are very commonly used, however, especially salicylic, benzoic, boracic, hydrofluoric, sulphurous and sulphuric acids; sulphites of soda or lime; borax, phosphates, formaldehyde, etc.

The fact that corn syrups are consumed in very large quantities by all classes, young and old, in many cases forming a large part of the daily food supply, makes it absolutely necessary that the syrups should be pure and free from all deleterious substances. It is immaterial whether the substances mentioned are introduced into syrups and into the system in heroic or homœopathic doses;

they can only do harm and should be kept out. Their medicinal properties make them unsuitable as constituents of food products and they are absolutely unnecessary. The only necessary preservative to guard against the spoiling of syrups is:

I. Sufficient body; a specific gravity not below 42° B.

II. Sterilizing when filling the containers.

III. Air-tight packages.

IV. Absolute cleanliness in the process of manufacture.

The largest manufacturers of corn syrups use these means, and only these to preserve their products.

The retail price of corn syrups is as low as 10 cents for a 2½ lb. can. There are very few food articles on the market today that are as cheap and pure or as wholesome and nourishing as the common corn or glucose syrups.

DETAILS OF AN EXPERIMENT IN COMPOSITION OF FORCES.

BY W. C. HAWTHORNE,

The Harvard Preparatory School, Chicago.

In none of the elementary texts on physics with which I am acquainted are the conditions of equilibrium with parallel forces worked out completely by the laboratory method. It has been my custom to give the following directions for an experiment to be performed by the pupil, after having taken up a few preliminary ideas as to the effect and representation of force.

A STUDY OF PARALLEL FORCES.

Object.—To find the conditions of equilibrium when the forces are parallel.

Material.—A "checker board," twelve inches square, with rows of holes one inch apart each way. The horizontal rows are numbered, the vertical rows are lettered. Four spring-balances, registering to one ounce. A peg or nail, attached to the ring of each balance by a string ten or twelve inches long. By this means a force in any direction may be applied at any point on the board. In order that the board may move with little friction, it is mounted on marbles which rest on a smooth surface.

Directions.—Case I. Apply a force of 24 to the northward at C6

and a balancing force at F6. What is the line of action, the direction, and the magnitude of the balancing force? [Repeat if necessary until the pupils see that two forces in equilibrium must act in the same straight line, be opposite in direction and be equal in amount.]

Case II. Apply a force to the northward at C6 and a balancing force at C7 (?). At C8 (?). At C9 (?). What effect does it have on a force to change its point of application along its line of action?

Call forces to the northward plus; to the south, minus.

Case III. Balance a orce of +24 at E6 by two negative forces. one at D6 and one at G6. By two negative forces, one at C6 and the other at G6. By two negative forces, one at C6 and the other at I6. What is true of the sum of all the forces, positive and negative in each trial? [Ans.—The sum of all the forces, positive and negative, acting upon a body at rest, must be equal to zero.]

Case IV. Imagine the board pivoted at C6, so that it may turn freely in either direction. Compare the turning effect produced by a force of +30 at D6 with that produced by a force of +30 at F6. With +15 at H6. With +30 at B6. With −30 at F6. With −30 at B6.

Define moment of a force. How is it found? If distances to the right of the axis are called positive and those to the left negative, show that a moment may be positive or negative, and give examples of each. Define positive and negative moments with reference to the motion they tend to produce, as compared to the motion of the hands of a clock.

Apply forces as directed below, balance them by other forces, and fill out blanks. Axis at B6.

HOLE	DISTANCE	FORCE	MOMENT
D6	?	+40	+?
C6	?	30	+?
G6	?	?	+?
Sum			

Calculate anew the *distances* (of forces from the axis) and the *moments* when the axis is taken at some other point, as H2. (Remember that the *distance* or *arm* of a force is the perpendicular distance from the axis to the line of action of the force.)

State law of moments of forces in equilibrium.

With the above work and its meaning firmly fixed in the pupil's mind, all problems concerning the lever and its applications are easily solved. The idea of couples may then be worked out for another experiment, when they have the final law governing the equilibrium of parallel forces: The sum of the moments of the couples must be equal to zero. By this principle many problems

may be easily solved that present difficulties when attacked by the law of the triangle of forces, as for instance the forces acting on the hinges of a door, the weight and dimensions of the door being given.

In conclusion, let me say that no originality is claimed for anything here, of course, but the method of presentation. This method has given good results in my classes.

THE CIRCULATION OF THE BLOOD.

BY W. H. MANWARING,

Johns Hopkins Medical School.
Formerly Professor of Physiology and Hygiene, State Normal School, Winona, Minn.

In a note in one of the recent numbers of this journal, a vivisection method was given for the demonstration of the circulation of blood in the web of a frog's foot. I believe, and believe most strongly, that anything approaching a vivisection method should be absolutely forbidden in the public schools. The anti-vivisection craze, that has caused so much inconvenience to medical research, was born and fostered from just such experiments, performed by unskilled teachers, before impressionable and immature pupils. There is only one place in elementary physiology where a vivisection method is necessary, and that is in the making and experimenting with a muscle-nerve preparation.

Not only is the resort to vivisection methods unnecessary in the demonstration of circulation, but circulation can be demonstrated much more easily and in a more striking way without it. Probably the easiest method is by the use of minnows. A very small minnow, if placed on a bit of moist absorbent cotton on the slide of a microscope, will generally remain quiet for some time, and the picture obtained by observing its tail or dorsal fin is one of the most striking the high-school student sees. The large arteries breaking up into smaller ones and these, in turn, into capillaries, the union of the capillaries to form the veins and these, the venous trunks, all can be seen in one field of view. When the observation

is over, the little fish can be returned unharmed to the aquarium, to be forever afterwards an object of intelligent admiration by the pupils, and there is no impression of cruelty and hard-heartedness on their minds, the impression that is the strongest when a pithed or chloroformed frog is used.

The picture obtained by the use of small, or even quite full grown tadpoles is nearly as striking. These can be laid flat on the slide and held in place by a little cage of wood or plaster of paris. But a method that always creates the deepest impression is the demonstration of the circulatory system in the chick embryo of from 36 to 72 hours. These can be obtained by incubating fresh eggs in the laboratory or by the use of hens. The eggs should be opened under warm, physiological saline (0.7 per cent NaCl 37.5° C.; pure water, of course, kills the embryo), and observed by the class. With a pair of fine dissecting shears the germinal disc can then be removed and floated out in a watch glass. Under the dissecting microscope and the low power of the compound microscope, the entire circulatory system can be studied. The action of the heart and the flow of the blood can be seen with perfect distinctness, and in a way that creates the most vivid impression, and one that can hardly be obtained by any other method.

These observations, coupled with experiments with the syringe-bulb model and a study of the anatomy of the sheep's heart, give a clear idea of the circulatory system, with no recourse to what the laity will always rightly consider cruel and heartless methods.

BALANCE DETAILS.

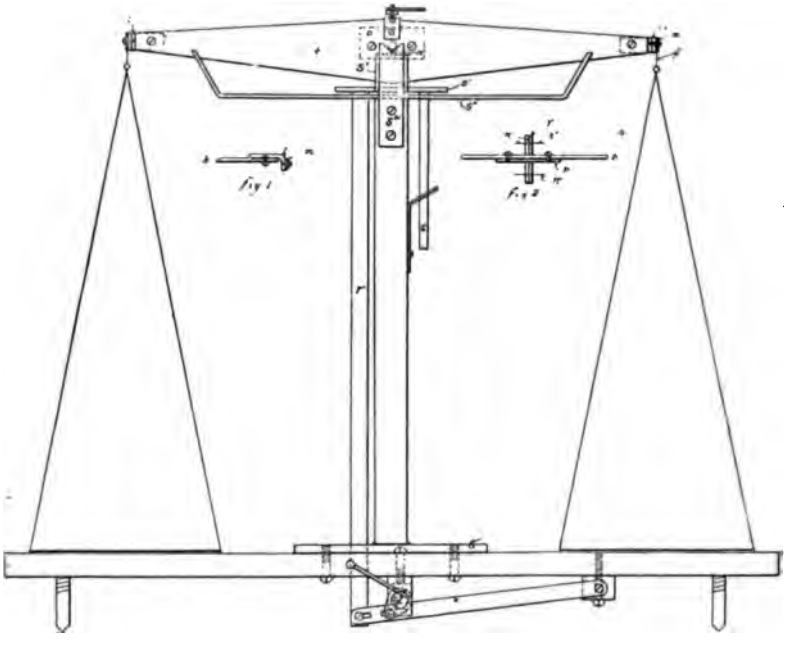
BY E. C. WOODRUFF.

Dept of Physics and Chemistry, The Lyons Township High School, La Grange, Ill.

The following plan for a balance of any desired sensitiveness and accuracy, and yet of a construction involving no very difficult operations and but little expenditure for material and tools, is offered as a suggestion to teachers who may not be able to buy quite as good balances of the conventional kind as they may need.

The chief object in designing the balance was to eliminate knife-edges, especially for supporting the pans, and to substitute something equally good for most work. Incidentally several other details in construction were simplified and brought within the powers of the man handy with ordinary tools.

The plan as drawn is taken from a balance in actual use, with but few changes in some minor details. The pointer is omitted



for the sake of clearness. The size of each part may be deduced from the length of the beam, 8 1-2 inches between pan supports. The beam is of 1-16 inch sheet aluminum, the pans and hangings from very thin aluminum sheet and wire. The remaining parts are all of brass, with the exception of the fiber base and the bearings for the beam and pans. Parts *r*, *r'*, *r''*, *r'''* and *r''''* are brass rods and tubes, ½, ¼ and ⅛ inch in diameter. Parts *S'*, *S''*, *S'''*, *S''''*, *p*, *l*, etc., are of sheet brass ⅛, 1-16th and 1-32nd inch

in thickness. The standard, r'', is soldered to the base plate, S'''. The bent plate, S', which carries what corresponds to the agate planes in the conventional construction, is soldered to the lift and guide rods, r' and r'''. The bent plate, S'', is soldered to one of the plates S''''. S'' and S'''' receive the beam in four V-notches when it is lowered to change the weights. The mechanism below the base needs no explanation.

Taking up now the special features, the beam bearings and the pan supports, Fig. 1 gives a top view of the right hand pan support. Pinched between the plates l and m is a silk fiber or collection of fibers, f, and these fasten to the wires that support the pan. At one end the beam is slotted longitudinally so as to allow l to be adjusted to bring the points of flexure of the fibers equally distant from the beam bearings.

Fig. 2 gives a bottom view of the beam bearings and the parts of the lift in immediate contact therewith. n' and n'' are very fine cambric sewing needles. n' is soldered to the rod r, which rod is soldered to the plate p and fastened to the beam as shown. The needles, n'', are fastened to the edges of the U-shaped plate, S', and extend at right angles to n'. The radius of n' being very small, ordinary deflections do not change the relative lengths of arms of the balance appreciably.

The rolling friction between the supporting needles is so small and the resistance of the silk fibers to flexure is so slight, that the sensitiveness of the balance compares favorably with that of those having agate planes and knife edges. In ease of construction, adjustment and repair, and in stability in use, the knife edge construction is considerably exceeded. The balance from which the plan was drawn will easily give a deflection of two millimeters per milligram, and will carry a load of 200 grams.

Balances are in use constructed after the same general plans, but with the following modifications:

(1) One balance of six-inch beam and of a much lighter construction shows a deflection of ten millimeters for one milligram difference in load, and easily carries 50 grams in each pan. This balance represents a much more carefully made design than the first and is, of course, inclosed in a case.

(2) On the other hand, balances have been used with considerable satisfaction whose beams were of a close-grained wood, whose beam bearings were fastened to the top of wooden pillars, with no lifting mechanism, whose pan supports were held between L-shaped brass paper fasteners secured to the beam by wood screws, whose needles were about No. 3 in size; and yet they had a sensitiveness of 0.01 gram and a carrying capacity of $\frac{1}{2}$ kilo in each pan, combined with a practicability and a minimum of cost that meant much when equipment was deficient.

These balances, and other pieces of apparatus involving the same kinds of bearings of crossed cylinders and flexible suspensions of fibers bending where they are pinched in a crack, have been in use now for nearly ten years, and have proved more than satisfactory, considering the ease with which they have been made, their stability in action, and the sensitiveness and accuracy of which they are susceptible.

A SPECTROMETER.

BY JOHN LE MAY.
Instructor in Physics, Lake High School, Chicago.

A spectrometer suitable for the laboratory work of most secondary schools may be constructed without excessive expenditure of either money or labor.

A circular table *A* of seven-eighths inch wood ten inches in diameter is fitted closely to a one inch brass tube seven and a half inches long. It is fixed in place by roughening the brass tube and gluing. A circular block *B* is used to make the support firmer. A six inch circle of wood *C* serves as a base. The whole is rendered more stable by filling the lower half of the tube with Babbitt or other expansive metal. The Babbitt metal should be cast into the tube before the wood parts are fitted on.

The rotating table *D* is a three inch circle of wood one half inch thick, with a one inch hole three-eighths of an inch deep on the under side, to fit over the top of the brass tube. A pointer *E*

of one-eighth inch brass rod extends to within one inch of the edge of the table.

The telescope support *G* is carried on a revolving arm *H*, shown in plan in Fig. 2. A cylinder of lead one and a half inches in

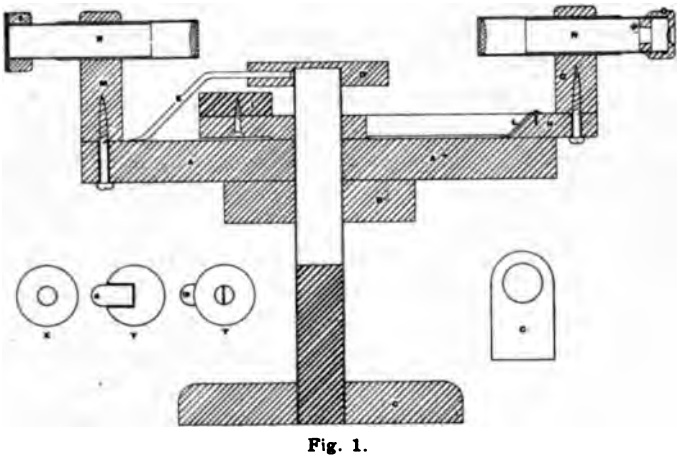


Fig. 1.

diameter and one-half inch high, *I*, serves as a counterpoise.

The telescope support *G* is fastened to the arm *H* by a single round-head screw one and a half inches long, the arm being bored to receive the shank of the screw. The support itself should be bored, to prevent splitting, with a hole somewhat smaller than the screw. An index *L* may be made of thin copper and screwed to the arm.

The collimator support *M* is similar to the telescope support,

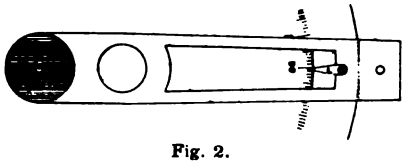


Fig. 2.

but it is half an inch longer, and it is screwed to the table, which is bored to receive the shank of the screw.

The telescope *N* consists of two three inch lengths of brass

telescope tubing, one thirty-second inch wall, three-fourths inch inside and outside diameters respectively, varnished inside with dead black varnish. The objective is a three-fourths inch achromatic lens, four inches focal length, cemented in position with shellac. The eyepiece is a five-sixteenths inch single lens, one-half inch focal length, cemented with shellac to a wooden ring *O* of cross-section shown. The ring *P*, fitting closely inside the draw tube, bears the cross hairs, which may be of human hair or very fine wire cemented in place with shellac. To set the cross hairs in position, remove the draw tube and, looking through the eyepiece toward a window, push the ring to such a position that the hairs are in focus.

The objective and tubes of the collimator *R* are similar to those of the telescope. The slit may be built up as shown at *S* and *T*. A cylindrical ring of wood *S*, one-half inch long, is fitted over the end of the draw tube and cemented in place. Pieces of a cartridge paper shaped like *X*, *Y* and *X* are glued on in succession. Care must be taken that no glue may get into the slot in which the slip *a* slides.

The wood parts may be varnished or painted black. The brass parts should be polished with fine emery paper, then warmed and laquered with white shellac dissolved in alcohol.

Eight inch circles on cardboard, divided to half degrees, are obtainable from dealers in draughting supplies. A one inch circle should be accurately cut in the center, to fit over the brass tube.

To adjust the instrument, first set the telescopes in line with each other and with the center of the table. Tighten the screws so that there will be no twisting of the telescope supports. Then focus the telescope on some distant object, and scratch the draw tube to mark its position. Place the telescope in line again, illuminate the slit and adjust the draw tube of the collimator until the slit is in focus. Mark the position of the draw tube of the collimator. Place the 0° line of the divided circle directly under the axis of the collimator, and cement the circle in position. With the cross hairs of the telescope on the image of the slit, adjust the index of the revolving arm to the 180° line, and the instrument is ready for use.

ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY.

BY GEORGE W. MYERS.

(*Continued from page 491, Vol. I.*)

Let the bolt at *C* be provided with a long, pointed head and fit a notched sight at *A*. Attach a plumb-line to the head, *C*, and allow it to hang freely in a vessel of water (battery cell or tin cup) supported by a stand, *S*, on the post, *EF*. Placing a carpenter's level on the top of *AC*, hold the quadrant so that the bubble will play, and start the graduations with the point which then falls just beneath the line near *B*, the graduations rising to 90 deg. at *A*.

If desired, a circular board, graduated and fixed horizontally to the post, *EF*, just below the stand, may be added, from which, by the aid of a pointer fixed to the post, *OM* or *PN*, horizontal angles, or azimuths, may be read. All measurements of altitude and azimuth which are made with a universal instrument may be roughly made by this apparatus, if the objects used are bright.

EXPERIMENT XXIV.

To make a wooden quadrant for hand use.

Join two ¾-inch surfaced boards together, reinforcing them by cleats, if necessary, and cut from them a quadrant of radius 18 inches, as suggested by the accompanying figure. Graduate it, and provide it with a plumb-line, as shown. By means of a handle attached as represented in the edge view, altitudes of naked-eye objects may be measured by hand, much after the fashion of the simplest forms of the sextant. The sight-line, *SC*, is determined by a notched sight at *S*, and a pin or nail at *C*. The graduation lying just beneath the cord at *D*, when the sight-line is directed to the object, furnishes the angular elevation of the object above the

*For the convenience of those who may desire to use these experiments (there are forty-four of them) in their clases, they may be obtained in pamphlet form from "The School Science Press," Ravenswood, Chicago, at 25 cents a copy, and $2.50 a dozen.

horizon. The reading may be very much facilitated by an assistant. Altitudes of the moon, of the brighter stars, and with the use of colored glasses to protect the eyes, of the sun may be

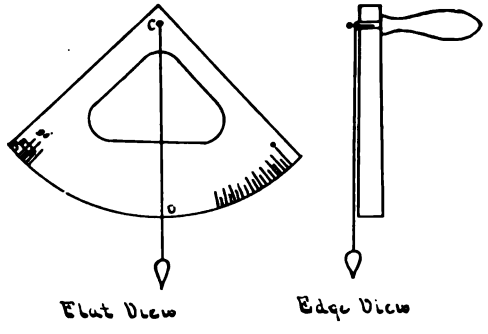


Fig. 24.

measured with rather surprising accuracy with this device, after a little practice.

Experiment XXV.

Construct a Tycho's quadrant.

If the quadrant, *ACBD,* of the last experiment be made smaller and lighter, and a pin be inserted at *C* to serve for a handle, the quadrant may be supported by hand. In this case an assistant observer will note the reading which falls under the plumb-line.

Experiment XXVI.

Construct a plumb-line gnomon.

Surface a board (*DE.* Fig. XXI), 2 feet by 3 feet, and fix two uprights, *A* and *B,* vertically upon it. Tie the uprights with a cross-piece, *C,* at the top, and suspend a plumb-line, provided with a sliding bead, from the middle of *C.* Varnish or paint the surface, and with thin wedges at *G* and *H* level the board carefully with a spirit level and mark the point just beneath the lower tip

of the bob. Hereafter the board may be leveled by sliding the wedges in and out until the bob hangs just over the designated point. With this point as a center, describe a series of concentric circles with radii varying by one inch (or by ½ inch). By noting the instant when the forenoon shadow of the bead crosses (or touches) any circumferences and the instant when the afternoon shadow crosses the same circumference, the time of apparent noon is given by taking one-half the sum (the mean) of the times of the two suggested instants.

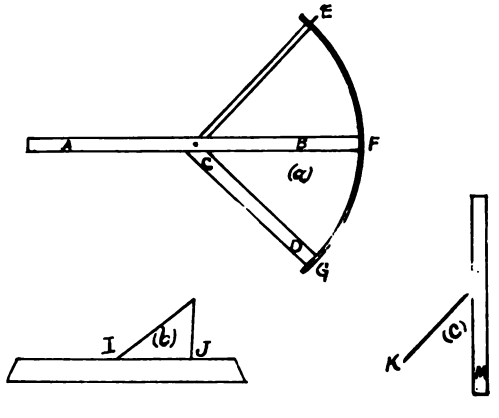
To find the meridian, see Experiment XX, (a), (2).

Experiment XXVII.

Construct a horizontal sun-dial.

Apparatus for graduating a horizontal dial.

Cut out and surface two wooden circles of 12 inches diameter and fit the half of one to the other at an angle of 48° (the



(a) = Graduating Apparatus,
(b) = Horizontal Dial,
(c) = Vertical Dial,

Fig. 25.

colatitude of Chicago). Erect at the common center of the circles a wooden or iron rod, making an angle of 42° (the latitude)

to the whole circle, and on the side opposite to the one on which the half-circle is fitted, as indicated in the figure. Cut the rod off to a length equal to the radius of the circles. Fasten one end of a flexible strip of copper, *EFG*, the length of which equals a quadrant of a circumference whose radius equals the radius of a circle, to the top end, *E*, of the rod, leaving it free to turn.

Graduate the circle, *CD*, whose plane is perpendicular to the rod, *CE*, 5° or 10°, then by putting the end, *G*, of the copper strip, *EFG* (free to turn about *E*), at the successive points of graduation of the circle, *CD*, corresponding points may be transferred to the circumference of the full circle, *AB*, which, being connected with bottom of the rod, will indicate the consecutive positions of the shadow of the rod for twenty and forty minute intervals of time. This completes the apparatus for graduating the dial.

To make the dial:

(a) Insert a smooth stick in a surfaced board at an angle with the surface equal to the latitude of the place. Describe about the foot of the stick a circle of radius of six inches and transfer to this circle, from the point directly under the end of the stick, the graduations of the full circle of the graduating apparatus described above.

(b) Instead of the inclined stick the edge of a triangle may be used, whose angle, *HIJ*, is the latitude.

Experiment XXVIII.

To make and graduate a vertical dial.

On the south side of a vertical surface attach a triangle (or a rod, *KL*, foregoing cut) so that its plane shall be perpendicular to the vertical surface, *LM*, and its hypothenuse, *KL*, shall make an angle equal to the co-latitude (90 deg.—latitude) with this surface.

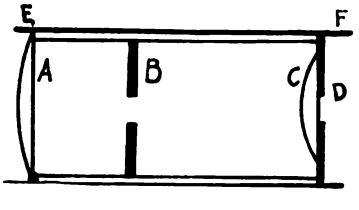
To graduate the circle *LM*, an apparatus like the one for the horizontal dial may be used, save that here the angle *E C F* must be the *co-latitude* (90 deg.—latitude), and the angle *F C G* must here be equal to the *latitude* of the place.

Experiment XXIX.

To construct a negative, or Huyghenian, eye-piece.

Procure two plano-convex lenses, one of $\frac{3}{4}$-inch diameter and 2 inches focal length, and the other of $\frac{3}{4}$-inch diameter and $\frac{3}{4}$-inch focal length. Roll up around a cylindrical stick, 5-8 inch diameter, heavy manila paper, using 6 or 7 ply, a cylindrical tube. The successive layers of paper may be stuck with library paste.

When the cylinder dries, cut off a piece of $1\frac{3}{8}$ inches, square the ends, and fit the lenses as suggested by the figure. Before attaching the lenses to the tube, cut from the center of two circular pieces of pasteboard a smooth hole $\frac{1}{4}$-inch in diameter, as at *B* and *D*. After pasting the edges of the first disk, stick it in the tube $\frac{3}{4}$ inch from one end, *D*, where the 2-inch focal lens is to be attached. The edges of the lenses may be stuck to the paper by means of gold-size. Complete the eye-piece as suggested by the cut. The completed eye-piece should be covered with a layer of tissue paper, the edges of which are allowed to extend beyond the ends of the tube, as shown at *E* and *F*. The ends should then be



Eye-piece.

Fig. 26.

stuck down around the edges of the lens, *A*, and of the pasteboard disk, *D F*.

(N. B.—This exercise is due to Dr. George Pyburn, and was published in *Popular Science Monthly*, Vol. XXIV., No. 1. The article is also reproduced as *Appendix A* in Miss Byrd's *Laboratory Manual.*)

Experiment XXX.

To make a telescope.

Obtain a 1½-inch x 30-inch achromatic object-glass, *O*, and roll up tubes of manila paper, stick with glue or library paste, and make a cell (as *c*) around it. Then roll up a tube, *T*, 30 inches long, and a draw tube, such as *D*, some 15 inches long. Provide the back end of the draw-tube with cardboard flange, *F*, and roll up smaller tubes to fit, as indicated in the figure. The collars, *G G* and *H H*, may be made by rolling narrow strips of manila paper about the tube, *A*, until they just fit inside *D*. A strip of broadcloth, just wide enough to wrap once around the outside of *a*, should be glued to the outer surface of *a* to insure smooth sliding of *a* within *A*. The eye piece was fully explained in Experiment XXVIII.

(See *Appendix A* of Miss Byrd's *Laboratory Manual.*)

(See Fig 27, next page.)

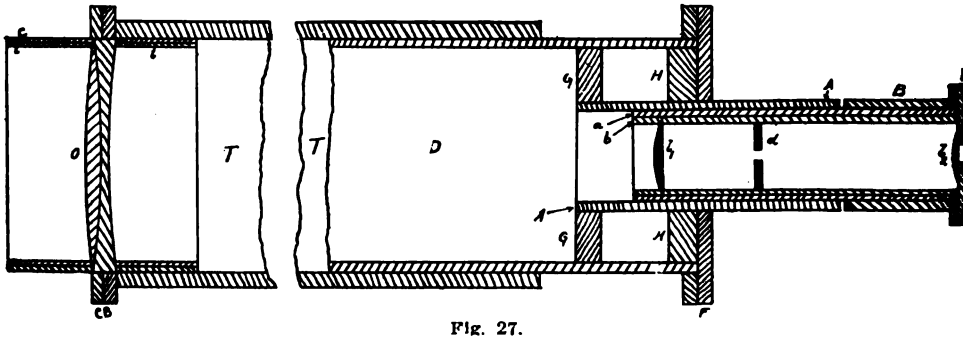


Fig. 27.

O.	Objective.	*B.*	Covering for eye-piece.
C.	Cell and cap.	*C B.*	Flange of Pasteboard.
i.	Inner tube to hold cell.	*F.*	Flange.
T.	Main tube.	*l1* and *l2.*	Eye-piece lenses.
D.	Drawtube.	*d.*	Shoulders.
a.	Eye-piece adapter.	*G* and *H.*	Perforated diaphragm.

(*To be continued.*)

Metrology.

DECADENCE OF THE VULGAR FRACTION.

BY RUFUS P. WILLIAMS.

(*Continued from page 405, Vol. I.*)

Opponents of the metric system argue that in the great marts of business, the chambers of commerce and stock exchanges, the tendency is away from decimalization. This is not true.

Stocks are quoted in whole numbers, quarters and eighths, because they have always been so quoted and there would be some little difficulty in changing at any given time, owing to adjustment of accounts on a new scale. In the continental bourses quotations of local stocks are in tenths, whereas shares of United States and English companies must be quoted as in their own exchanges or else reduced to parity. But while the quotations in our exchanges are expressed in eighths, the bookkeeper employs the decimal system in computation. Suppose the stock sells at 61⅝, the accountant writes 61.625, and if the customer buys 100 shares he writes 6162.50, thus changing aliquot parts to decimals, and saving much time. In some exchanges, like the New York Consolidated, this system is further accentuated by trading in multiples of ten shares only. Both these facts show a tendency to break away from the cumbersome old divisions. In most exchanges the only round lots are hundred shares or their multiples, and the par value is usually 100 or a decimal part of it.

The Cotton Exchange illustrates clearly the tendency referred to. Trading in cotton futures was not practised till after the close of the Civil War, spot cotton being quoted like other stocks in cents, halves, quarters, etc. When provision was made for quoting futures it was decided to employ the most modern method, and they have always been given in cents, tenths and hundredths, whereas spot cotton is to this day quoted by the old terms. Bookkeepers say it is easier to keep the accounts for "futures" than for "spot." Several other commodities, like pork, lard, coffee, etc., which

have lately been listed on the exchanges, are quoted only in decimals. The advance or decline in sugars, etc., when quoted at wholesale, is in cents, tenths and hundredths. Thus do the facts from the great business centers show the preference for decimalization in a very marked degree.

It remains to note a few of the facts and events of daily life in which records are kept in multiples of ten or in decimals of the unit: humidity, dew point, rainfall, sunshine, readings of barometer and thermometer, comparative average of crops, and crop reports of all kinds, sanitary conditions, mortality in general and in particular diseases, measurement of athletes, lifting and other capacities of strong men, comparisons of all sorts of athletic sports and events, transportation rates of grain, milk, etc., speed of trains and of vessels, rise and fall of tides and rivers, bank clearings, registers for street car fares, gas meters, vernier readings, and almost all automatic records of every sort. Stop watches record the fifth of a second—practically a decimal division. Reunions come on decades. We even record hours and minutes as though they were decimals.

The rooms of large office buildings of late construction correspond in hundreds to the floor number; for example, all rooms on the fifth floor are numbered from 500 up, and those of the sixth floor begin with 600, though the last room on the fifth floor may be 524. To some extent the same is done in street numbering, as between fifth and sixth street the numbers may run between 500 and 600. In many cities the numbering of residences and blocks is on a basis of ten, a new number being assigned to each 10 linear feet. This list might be continued *ad infinitum*. Take any newspaper and search for tables of comparisons on any subject whatever, and almost invariably you find fractions expressed decimally.

The only practical logarithmic base which has survived the last 300 years since Napier invented logarithms is the decimal one. Great importance is attached by teachers of arithmetic to the rapid mental solution of questions involving common fractions. Under existing conditions this is necessary; but it is questionable how great this value will be when the computations of daily life correspond still more nearly with those of the scientist and mathe-

matician. French arithmetics have far fewer common fractions and far more decimal than ours, and teaching in the schools of France is correspondingly simplified. The early arithmetics (as Pike's, 1788-1832) put great stress upon the superiority of Federal over English and other moneys. People are now so accustomed to this they forget that the advantages are no less when applied to measuring, weighing, and the other arts of life. As the banker in counting bills stops involuntarily at each ten to moisten his fingers, so counting by tens gets to be a habit in all intellectual efforts.

Such facts as these have a direct bearing on the metric system. Decimalizing the inch, the foot or the chain is a mere make-shift; the subdivisions created in the case of each are incongruous with the other two: 100 inches = 8.33 1-3 feet; 10 feet = 15 15-99 links; 1 link = 7.92 inches. The effort to introduce such decimalizations accentuates the desirability of a decimal scale acceptable to all peoples. What would be thought of a device—for example a gas meter or a car fare register—which recorded 12 on the lowest scale, 3 on the next higher, 5½ on the third, etc., after the manner of our linear measure, instead of a uniform scale ascending regularly by 10 or 100? The former scale could never for a moment compete with the latter, and no inventor or manufacturer would care to try the experiment. Can one reflect upon this fact and still believe that the metric system of weights and measures is not better than the one now in use?

NOTES.

The Metric Movement in Congress.—In response to a summons of Chairman J. H. Southard, several large manufacturers recently appeared before the House Committee on Coinage, Weights and Measures, to discuss the advisability of adopting the metric system. Among others was Prof. Elihu Thompson, of the General Electric Co., who presented the written views of many mechanical engineers, all of whom favored the adoption of the system. While he estimated the cost of change in the

have lately been listed on the exchanges, are quoted only in decimals. The advance or decline in sugars, etc., when quoted at wholesale, is in cents, tenths and hundredths. Thus do the facts from the great business centers show the preference for decimalization in a very marked degree.

It remains to note a few of the facts and events of daily life in which records are kept in multiples of ten or in decimals of the unit: humidity, dew point, rainfall, sunshine, readings of barometer and thermometer, comparative average of crops, and crop reports of all kinds, sanitary conditions, mortality in general and in particular diseases, measurement of athletes, lifting and other capacities of strong men, comparisons of all sorts of athletic sports and events, transportation rates of grain, milk, etc., speed of trains and of vessels, rise and fall of tides and rivers, bank clearings, registers for street car fares, gas meters, vernier readings, and almost all automatic records of every sort. Stop watches record the fifth of a second—practically a decimal division. Reunions come on decades. We even record hours and minutes as though they were decimals.

The rooms of large office buildings of late construction correspond in hundreds to the floor number; for example, all rooms on the fifth floor are numbered from 500 up, and those of the sixth floor begin with 600, though the last room on the fifth floor may be 524. To some extent the same is done in street numbering, as between fifth and sixth street the numbers may run between 500 and 600. In many cities the numbering of residences and blocks is on a basis of ten, a new number being assigned to each 10 linear feet. This list might be continued *ad infinitum*. Take any newspaper and search for tables of comparisons on any subject whatever, and almost invariably you find fractions expressed decimally.

The only practical logarithmic base which has survived the last 300 years since Napier invented logarithms is the decimal one. Great importance is attached by teachers of arithmetic to the rapid mental solution of questions involving common fractions. Under existing conditions this is necessary; but it is questionable how great this value will be when the computations of daily life correspond still more nearly with those of the scientist and mathe-

General Electric Co.'s works at $150,000, he said this would eventually be saved in reduced cost of computations, etc.

Mr. James Christie, superintendent of the Pencoyd Bridge & Iron Works, the largest bridge works in the world, thought that $500 would cover the cost of change in his shops.

Mr. Troemner, manufacturer of scales and weights in Philadelphia, said that the only expense as regards common balancing scales would be in the change of weights, which, for the average country store, would not cost over five dollars.

Dr. A. E. Kennelly stated that electrical engineers dealt in units of the metric system to a large extent, and would be glad to have the system used in all branches of mechanics.

R. P. W.

In Parliament.—The Decimal Association has published a list of 229 Members of Parliament who favor the compulsory use of the Metric System and says there are 30 more who withhold their names, though in favor of the measure. This makes 259 Members favorable to the cause out of a total membership of 670 in the House of Commons.

R. P. W.

Notes.

BOTANY.

Reference has been made in these columns to the College Entrance Option in Botany, formulated by a Committee of the Society for Plant Morphology and Physiology. This Option has been adopted officially by the College Entrance Examination Board (of the Middle States and Maryland), and is published in their Document No. 8, issued Jan. 10, 1902. It was decided by the Society, at its recent meeting in New York, to publish a new edition of their Report containing the Option, and notice of its appearance will be given in SCHOOL SCIENCE.

Smith College, Northampton, Mass. W. F. GANONG.

A Simple Wardian Case.—As no direct answer from anyone with experience has been received to the question (30) in the May, 1902, number of SCHOOL SCIENCE, about a simple window case, we quote the following from Ganong's "Teaching Botanist":

"Have made a covered galvanized iron box the length of the window two feet wide and three inches deep, with a hole in one corner

for filling, and a tight sheet-iron hood beneath to shield the flame and keep gases from rising through the joints of the case; have sashes made with as little wood as possible to surround and cover it l....; on one of the long sides two doors must be left, which can be tightly closed; the top may be hinged to allow opening for ventilation at times; support the whole on a firm table; shelves of glass or wire netting may be added; use preferably a Koch safety burner (which shuts off the gas if the flame goes out) and a Reichert regulator. The entire cost should not exceed $25 to $30. It should not be built into the window, at all events not without an extra sash some inches from the window sash." Illustrations are also given.

GEOLOGY.

Many teachers of geology desire to present to their students an account of the past life of the earth in a manner that shall appeal to the greatest interest. Until now the remains of the vertebrate life of the past ages have been described in technical works largely, and either skeletons or very imperfect and inadequate restorations have been offered as illustrations. These are misleading or present no idea to the student of the animals' actual form; it is only in the last few years that it has been possible to restore the appearance of the forms with any degree of confidence in the accuracy of the picture. Recently two books have appeared from the press of D. Appleton & Co., which go a long way towards solving the difficulty. *Animals of the Past,* by Frederic Lucas, is a popular account of the life and habits, so far as known, of the most important or at least the most thoroughly known forms, and is well illustrated by drawings and photographs of models, mostly the work of Chas. Knight, of the American Museum of Natural History. *Dragons of the Air* is a somewhat more lengthy account of the Pterodactyls of the Mesozoic time. Perhaps no forms have more needed a clear and accurate describer to free them from the mass of monstrous structures that has been foisted upon them by uncertain describers, and in this book we have an account with good figures that may be depended upon as a step toward accuracy in representation.

Another book of very great value to the busy teacher of geology is a *Syllabus of Economic Geology,* by Branner and Newsom, Leland Stanford University Press ($2.75 by mail). This book presents in a very direct and clear fashion a good course in economic geology, and while it contains far too much to be given in the ordinary course in general geology, it will serve as a guide to the collection of the most

valuable material for presentation to a class. It is illustrated with many useful figures and diagrams.

In the October-November number of the Journal of Geology are two articles upon the principles of classification of the geological deposits. The first, by Prof. Bailey Willis, of the United States geological survey, deals with the individuals of the stratigraphic classification and is devoted especially to the value of the lithological characters of the deposits and their interpretation. The second, by Prof. H. S. Williams, has to do with discrimination of time values in geology and deals largely with the value of fossils as measures of time. A scheme of time description is proposed with new terminology. Both of these articles deal with the fundamental principles of classification of deposits and are of wide interest. An editorial in the same number promises a continuation of articles upon the same and related subjects and a full discussion. The next articles to appear will discuss the classification of minerals and rocks.

The address of the President of the Geological Society of Washington, Mr. J. S. Diller (SCIENCE, Vol. XV., No. 371), contains a description of the history and loss of the great mountain Mazama, which previously stood over the site of Crater Lake, Oregon, and presents the matter in the clear and direct style which has made Mr. Diller's work of the greatest use to teachers and students, notably the Bulletin 150 of the U. S. Geol. Survey, which described the collection of rocks prepared by the Survey for distribution. The address, entitled "The Wreck of Mt. Mazama," begins with a brief history of the Cascade Range. The states of Wyoming, Montana, Idaho, Washington and the northern portion of California, comprise what was in early Neocene time an active volcanic area, which is as large as any in the world. "The western limit of this great volcanic field is marked by the corresponding border of the Cascade Range, which is made up at least largely, if not wholly, of volcanic material, erupted from a belt of vents extending from Northern California to Central Washington. Lassen Peak marks the southern end of the Cascade Range, and Ranier is near the northern end. Beyond these peaks the older rocks rise from beneath the Cascade Range and form prominent mountains, the range itself occupying a depression in the older terranes."

At the end of the Cretaceous time the coast of Northern California, Washington and Oregon subsided and the sea reached the base of the Sierra Nevada Range and covered most, if not all, of the present site of the Klamath Mountains. In Washington it reached as far as Mt. Ranier, and in Oregon to the Blue Mountains. The Cascade Ranges rest upon a base of the Cretaceous rocks, in a depression which extends from the Klamath Mountains to the Sierra Nevada and the Blue Mountains. This region has not remained as a depression, but has been ele-

vated; but the Klamath and Blue Mountains and Sierra Nevada have risen so much more rapidly that a depression would appear, if it had not been filled with the great lava flows which formed the Cascade Ranges.

In Eocene times the area described was elevated and largely eroded, and then the western portion depressed as far east as Roseburg, Oregon. There was little volcanic activity during the Eocene.

During Miocene time the volcanoes reached their greatest activity; though there is no evidence that any are active at the present time, the features of post-volcanic existence are, still apparent in hot springs, solfataras, etc. Mount Shasta and Lassen's Peak probably remained active until the Glacial time.

The author then describes the appearance of Mt. Mazama as it probably was before its destruction and as it appears today. It was, in all probability, as high as Mount Shasta (14,380 feet), and of quite similar appearance. The character of the lavas and the probable history of growth are next reviewed, and the characters of Crater Lake are discussed in relation to the pre-existing peak. When the wreck of the mountain occurred, 6,000 feet were removed from the level above the edge of the caldera occupied by Crater Lake. Calculating the size of this cone and the contents of the caldera, an amount of material equal to 17 cubic miles has disappeared from the mountain. The author proposes two theories to acount for this loss: first, explosion, and second, subsidence. At this point, Mt. Union, eight miles southwest of Crater Lake, is cited as a volcano in which the hard lava of the neck has resisted the wear of the elements and stands up above the worn-down tuffa cone, which originally surrounded, and Mt. Thielsen (twelve miles north), as a volcano in which the lava subsided in the neck after the last eruption. The last of the two theories proposed is regarded as almost certainly the true cause of the loss of the top of the mountain, though no lava flow is known which would account for the lost material, such as occurs of the Hawaiian volcanoes when the surface of the lava in the neck is lowered.

The whole address is of the greatest value to students, and might almost be presented as a class exercise as it stands. It is especially valuable as supplementing the material already at hand upon Crater Lake. It is probable that the address will be published as a Bulletin of the Geological Survey, with maps and figures. This will be a very welcome addition to teaching material, and it is to be hoped that the edition will be sufficiently large that it will not be exhausted as quickly as was the author's Bulletin of the U. S. Collection of Rocks.

E. C. C.

Book Reviews.

Supplementary Readings in Physics; The Air; Energy—a Constant Quantity; The Molecule; Weight. By J. A. CULLER. 12x18 cm. 16 pages. O. T. Corson, Columbus, O., 1901. 5 cents.

"The aim in this series of pamphlets is to apply the principles, rules and formulæ of the text-book on Physics to the actual and practical work of man and nature. Most pupils after a hasty study of Physics come from school with many hazy notions about many of the most important principles of science, because their minds have not been directed to the principles applied.

"It is hoped that these papers will aid in securing a deeper interest, starting real thought, and setting up this connection between the book and actual transactions.

"The most important subjects in Physics will be developed after this fashion, and the plan is to have enough of these pamphlets as property of the high school so that, from time to time, they can be given out as these subjects are being discussed, and again taken up and preserved for future classes."

This enterprise of Supt: Culler, as outlined in the above quotation, has much to commend it, and it is to be hoped that subsequent numbers of the series will follow in rapid succession. It is also to be hoped that the author will apply to himself what he so well says on page 13 of the pamphlet on "Weight" and will make some use in the rest of the series of the metric system, which he so earnestly advocates.

Books Received.

Modern Chemistry—By Fredus N. Peters. Maynard, Merrill & Co., New York, 1901. 412 pages, $1.10

A Laboratory Manual of Physics—By Henry Crew and Robert R. Tatnall. The Macmillan Company, New York, 1902. xii and 284 pages, 90 cents.

The Wide World. Ginn & Co., New York, 1902. vi and 122 pages, 30 cents.

Northern Europe. Ginn & Co., New York, 1902. vi and 122 pages, 30 cents.

Reports of Meetings.

NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

The general aim of this Association is to discuss and, if possible, to determine the best methods of teaching botany, zoölogy and physiology in secondary schools.

The Association is in a most flourishing condition, several new members having been added during the past year. Three of the meetings in each year are held in Manhattan and two in Brooklyn, thus giving teachers from both parts of the city an opportunity to take part.

The fifth meeting of the Association for the year 1901 was held on Dec. 6th, 1901, at the Ethical Culture School, 109 West 54th street, New York City. Several new members were elected and three interesting papers were read. Miss Florence Slater (Flushing High School) read a paper on the "Teaching of Entomology in the Secondary Schools." The secretary is unable to report fully on the paper. Dr. George M. Donaldson (DeWitt Clinton High School) spoke of the "Social Aspect of the Teaching of Physiology in Secondary Schools." The pupil, through the analogy of cells and the body to organized society, may be taught the scientific principle of division of labor. Mr. H. R. Linville spoke on "Some Practical Hints on Class Work with Living Animals." He mentioned at the outset four requisites for profitable work with living animals: First, familiarity with the general habits of the animals in nature; second, the possession of an abundant supply of active specimens; third, a carefully planned set of observations to be made; fourth, a freedom from bias as to what ought to happen, and a quickness to notice and to use the thing that really does happen.

Profitable work can be done in secondary schools on at least the following living animals: Any protozoa, hydra, with small classes, earthworms, nereis, crayfish, grasshoppers, slugs and mussels, with very small classes, fish, frogs and tadpoles.

The normal visible activities of three animals, the earthworm, sandworm and crayfish, were then described with a view to showing that practically all the better known functions of these animals can be observed and partially explained by young students. Acids or other wholly inexperienced stimuli should not be employed, because they confuse the normal reactions.

Besides acquainting students with the habits of more or less unfamiliar animals, these studies may be used to make interesting comparisons with similar functions in the body of man, and also to help the

student to understand more clearly than they could otherwise the relation existing between structure and function.

The first meeting of the Association for the year 1902 was held on the evening of Jan. 31, 1902, at the home of Dr. E. F. Byrnes, 43 Hancock street, Brooklyn, with Dr. Maurice A. Bigelow in the chair. Two interesting papers were read, one by Miss E. F. Byrnes (Girls' High School, Brooklyn) on "The Pedagogical and Ethical Content of Biology in Secondary Schools," and another by Miss Marion Brown (Erasmus Hall High School, Brooklyn) on "The History of the Teaching of Zoölogy in the Secondary Schools of the United States. (Abstracts of these papers are given below.) The officers for the ensuing year elected at this meeting are: President, Henry E. Linville (DeWitt Clinton High School); vice-president, Miss E. F. Byrnes (Girls' High School, Brooklyn); secretary, George W. Hunter Jr. (DeWitt Clinton High School); treasurer, Miss M. F. Goddard (Peter Cooper High School).

THE PEDAGOGICAL AND ETHICAL CONTENT OF BIOLOGY.

(An abstract of Miss Byrnes' paper.)

The claim of biology to consideration as an "educational appliance" is based not only on its pedagogical content, but also on the furnishing of data, which are the foundation of the modern psychology and philosophy.

The careful observation of an animal or plant enables a pupil to form a "percept"—a distinct mental image. As soon as the pupil has studied several forms belonging to one and the same group, he learns to form a "concept" in the *type* form. His concept is an abstract representation of the various concrete illustrations of the group with which he is familiar. The fitting of a percept to the concept next involves comparison and leads to the formation of judgments by inductive reasoning.

The objective nature of the forms studied helps to secure interested attention, which, through interest, becomes involuntary toward the subject; and, moreover, it aids the pupil in memorizing.

Habits of observation increase the power of seeing and habits of forming concepts train the mind in distinguishing between essential characteristics and unessential details; hence the study is of value as a means of mental discipline. Moreover, because the scientific method requires proof in support of assumption, as a test of their truth, it inculcates an honest habit of thinking.

The chief educational value of nature study lies in its power to form "germ centers" of interest. The chief faculties appealed to in the child are powers of observation and imagination. In the consideration of adaptive modifications, reasoning is also called into play.

The best results, however, are to be obtained only by extended use

of the laboratory method. Even the imaginative faculty is powerfully stimulated by a contemplation of nature and the discovery of natural law.

The biological sciences are especially valuable in education as laying a foundation for the understanding of the newer psychology which bases its teachings on the Recapitulation Theory. Dealing as it does with the teachings of heredity, evolution and adaptation to environment, the study of biology may be considered essential for the elucidation of principles, which are not only important as scientific data, but may also be considered as full of moral significance.

THE HISTORY OF ZOÖLOGY IN THE SECONDARY SCHOOLS OF THE UNITED STATES.

(An abstract of Miss Brown's paper.)

The history of biology in the secondary schools of the United States covers about a century. Botany was first taught. Zoölogy was introduced about 1825, and its history may be divided into four periods: (1) 1825-1870, a period characterized by the natural-history phase of the subject taught according to the text book method; (2) 1870-1886, in which comparative anatomy was made the basis for work and the text was supplemented by verification by specimens; (3) 1886-1900, during which time comparative anatomy continued to be the basis for work, but real laboratory work was introduced and laboratory manuals were used; (4) from 1900 to the present time there has been a gradual tendency to combine the natural-history phase with the comparative anatomy of the two preceding periods according to the laboratory method and in connection with field work.

Text books are the surest indication of the tendencies of a period, and by means of them three general lines of improvement are to be noted: (1) progress in aim from the narrow ideal of religious and memory training to the broader conception of mental, moral and physical development; (2)) broadening of subject matter through the discoveries of eminent naturalists; (3) three stages in method, (*a*) narrative, (*b*) classification, (*c*) morphology, and at present the beginning of investigation.

Reported by GEORGE W. HUNTER JR., Secretary.

PHYSICS AND CHEMISTRY AT THE NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

Continued from page 505, Vol. I.

At the session on Saturday morning, December 28, 1901, the first paper was read by Mr. R. J. Kittredge, Union Classical School, Schnectady, N. Y., on "The College Entrance Preparation of Students as Viewed from the Secondary Man's Standpoint." A very brief abstract is as follows:

There is no uniformity in the requirements in physics set by colleges,

but since most high schools offer enough physics to cover the Regents' course and the list presented by the National Educational Association, the requirements are not a hardship. In most high schools and many colleges, science has a secondary place. There is little or no correlation between the different sciences, too little time is devoted to science in comparison with the classics.

The student who wants science should be given the chance to study science as widely and deeply as he is now required to study classics. Science teachers should advocate a science course of four years in which physics has the place corresponding to Latin in a classical course. An especial effort should be made to plan and adopt as uniform a course as exists in the classics. The college requirements might be readily adjusted to fit such a liberal preparation.

Fewer sciences—not more than four—should be taught in secondary schools.

The second paper was presented by Professor Charles M. Allen, Pratt Institute, Brooklyn, N. Y., on "Chemical Laboratory Experiments and Notes." He said (in abstract):

Classes in chemistry should be provided with a set of laboratory experiments having the following specifications:

(1) The experiments should be suited to the facilities of the school's laboratory and adapted to the needs of the class instructed.

(2) They should be sufficiently strenuous to call forth the best efforts of the student, and they should not inform him of results which, with a reasonable effort, he could determine himself.

(3) The list should include the standard experiments, some illustrating the latest developments, and, in deference to the modern trend of elementary chemistry, it should contain some quantitative experiments.

(4) They should have interjected a series of questions directing the attention to the important parts of the experiment, and the answers to which demand earnest thought, and thus break up the baneful habit of mechanically following instructions.

(5) They should be entirely separate from the text book, so that the text book can be kept out of the laboratory.

Such a set of experiments can be provided by the teacher by means of mimeographed or hectographed laboratory sheets bearing experiments selected, modified, or originated by the teacher. The only practical note book, as many teachers have found out, consists of detachable sheets, collected in a binder. The instruction sheets, being bound in with the "accepted" experiment notes of the student, make a record of laboratory work which is complete and satisfactory.

Mr. Frank M. Gilley then discussed the topic "How to Meet the Problem of Teaching Physics by the Laboratory Method in Secondary Schools." Mr. Gilley illustrated his method of teaching the whole class at once in the laboratory by means of two experiments, a simple one in

reflection from a plane mirror, and a difficult one involving the Wheatstone bridge. He showed that effective work can be done by teaching certain experiments to a large number at the same time, provided sufficient apparatus is available and the experiments chosen are adapted to this method of presentation. This paper was followed by a general discussion.

Reported by LYMAN C. NEWELL.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The thirty-second meeting of the Association was held at the Newton (Mass.) High School, Saturday, Feb. 22, 1902. There were thirty-two members and guests present. After the customary business, the secretary, Mr. F. R. Hathaway, read his annual report, which showed that the past year had been one of progress, especially in the publication and distribution of literature devoted to the teaching of physics. The annual report of the treasurer, Mr. George A. Cowen, revealed the fact that the Association is in a prosperous financial condition. The committee on current events, through its chairman, Mr. L. J. Manning, gave a summary of a dozen or more articles on physics, which have recently appeared in the magazines. Mr. F. M. Grunlau, Cambridge (Mass.) High School, was elected to fill the single vacancy. The following officers were elected for the ensuing year: President, Mr. Clement C. Hyde, Hartford, Conn.; vice-president, Mr. George W. Earle, Somerville, Mass.; secretary, Mr. N. Henry Black, Roxbury, Mass.; treasurer, Mr. George A. Cowen, Jamaica Plain, Mass.; three members of the executive committee, Mr. J. C. Packard, Brookline, Mass.; Mr. C. S. Griswold, Groton, Mass.; Mr. Charles R. Allen, New Bedford, Mass.

The business was followed by an informal address by Dr. F. A. Waterman, Professor of Physics, Smith College, Northampton, Mass., on "The Scope of an Elementary Course in Physics." The speaker called attention to the fact that the work offered for entrance to college is diverse. He attributed the diversity largely to the various aims of preparatory teachers, ranging all the way from utilitarianism to true natural philosophy. Both extremes are objectionable; the former because it emphasizes mere manual training, and the latter, while the nearer right of the two, is apt to lack practical value and scientific character. The aim in all preparatory work should be to teach a mean between these two extremes, a course which is really scientific. Such a course will select the best parts of all courses, it will arouse and hold attention, it will never be a series of mechanical processes nor a collection of dry theories. Its real nature will be to cultivate reasoning power. He said, in regard to improving the teaching in secondary schools, that teachers should constantly ask, "What am I doing this for?" A course should be called a failure, or at least very faulty, if students do not know its

object and aim. The teacher should constantly ask, "What is vital and what is incidental?" Such teachers have the proper perspective of physics. Again, improvement may be made by more careful thought regarding the ground to be covered. And here the aim of each teacher should be to teach the best course in the time and with the means available. Teachers should not retain poor courses simply because someone else seems to be making such a course successful. Teachers also should pay more attention to the order of presentation and to the relative importance of topics. More stress should be laid on mechanics, since it is fundamental, and special pains should be taken to make the whole course a unity, and not let it be a collection of different topics. The speaker concluded by mentioning the legitimate means of stimulating interest which he had found profitable. The first is a timely reference to history, such as a quotation from Gilbert or Boyle. The second is a constant account of contemporary investigations, laying especial stress on the object of the work. This makes physics a living subject and prevents students from studying it as if all had been said and done. And third, opportunity is constantly taken to emphasize the value of pure science; such work, for example, as is done by the German Reichsanstalt, and is soon to be done by our own National Bureau of Standards. In conclusion, the speaker, with pardonable enthusiasm, urged his hearers to teach constantly the fact that physics is a fundamental science and that no other science of equal value can be substituted for it.

After lunch, Mr. Charles R. Allen read a paper on "Gas Engines." The paper was illustrated by lantern slides and was an interesting and instructive treatment of the construction, operation and use of this kind of engine.

At the conclusion of the above program the members visited the factory of Stanley Brothers, manufacturers of the Stanley Automobile, and, through the courtesy of the firm, were shown the various parts, especially the motor, of this class of carriage.

Reported by LYMAN C. NEWELL.

NEW YORK PHYSICS CLUB.

The sixtenth regular meeting of the club was held on Saturday, Feb. 8, at Stevens' Institute, Hoboken, N. J., President J. S. Gibson in the chair. Before assembling for the regular meeting, the members inspected the different laboratories of the institute, especially the new Carnegie Laboratory of Engineering, which has just been completed and presented to the institute by Mr. Andrew Carnegie, of New York. This building contains, in addition to a large lecture room, reading room and offices, engines of various kinds, steam, gas and gasoline, and a complete equip-

ment for boiler and engine testing. At the meeting routine business was transacted, the constitution was amended so as to make eligible for membership any teacher of physics in New York or vicinity, also making the executive committee consist of the four officers and the retiring president. From the Committee on Apparatus, Mr. Jameson called attention to a form of apparatus, devised by Queen & Co., for illustrating the laws of accelerated motion. This consisted of an inclined plane of grooved metal, hinged and adjustable for different angles, fitted with an accurately turned ball. Electrical connections and a sounder made possible the time intervals involved. Mr. Ball, of Pratt Institute showed a simple and inexpensive form of oblique pendulum, which could be set at any angle, from the vertical to the horizontal, and by means of which all the laws of the pendulum could be demonstrated.

The club then listened to a lecture by Prof. Geyer, assisted by Prof. Ganz, both of Stevens' Institute, upon "Fluorescence," the lecture being illustrated by many interesting and instructive experiments.

Reported by R. H. CORNISH.

ASSOCIATION OF THE SCIENCE TEACHERS OF CENTRAL ILLINOIS.

The organization was effected in April, 1901, at a conference of high school teachers held at Bradley Institute, Peoria.

The object of the science association is to improve and adopt uniform courses in elementary science. To do this, committees have been appointed to outline the work and give lists of apparatus needed to conduct the course.

The chemistry committee reported at the meeting of last fall, and its outlines have been in use in some of the schools during the present year, where they have given very good satisfaction.

The complete reports of the biology and physics committees were made at the meeting held at Bradley Institute, Feb. 8th. These reports besides including an outline of the laboratory work in the different branches which should be considered a minimum for one year, included a list of the apparatus in three grades, with cost and catalogue number, so that a detailed description of the apparatus could be easily obtained. A list of reference books best suited to the ordinary high school was added.

These meetings have proved very profitable, as the conference is limited and every one has a chance to express his views and ask questions.

It is hoped in this way to obtain some definite results, which would not be obtained from the loose statements of requirements so often made by colleges and universities.

Reported by F. L. BISHOP.

Correspondence.

QUESTIONS FOR DISCUSSION.

Teachers are invited to send in questions for discussion, as well as answers to the questions of others. Those of sufficient merit and interest will be published.

36. *What is a good list of about a dozen quantitative experiments suitable for a class in high-school chemistry?*

Simple Solution—Chemical Solution—Solubility of Salts—Water of Crystallization—Neutralization—Law of Definite Proportions—Law of Multiple Proportions—Proof that the products of a chemical reaction weigh the same as the factors—The Immunity of manganese dioxide in preparation of oxygen from manganese dioxide and potassium chlorate. These experiments have been successfuly performed in Shortridge High School. See SCHOOL SCIENCE, May, 1901, page 144.

In addition, the following: Weight of a litre of air and of oxygen as given by Dr. Newell's "Experimental Chemistry," also equivalence of zinc, magnesium and aluminum from the same source. Also the weight of a litre of carbon dioxide. See SCHOOL SCIENCE, January, 1902, page 430.

It is not likely that all pupils will have time for all experiments, but each will be able to do some, and listen to the explanations of others.

GEO. W. BENTON.

37. *What cases of chemical arithmetic should a senior class in high school be required to master?*

Second semester pupils in chemistry ought to be able to handle, before the close of the year, the subjects included in such a book as Waddell's "Arithmetic of Chemistry,' up to page 68.

GEO. W. BENTON.

School Science

VOL. II] APRIL, 1902. [No. 2

THE AMERICAN PHYSICS TEACHER'S OPPORTUNITY.*

BY EDWIN H. HALL, PH. D.

Professor of Physics in Harvard University.

This opportunity is first the opportunity of every teacher of youth, the opportunity in some measure to guide, to instruct, to form the leaders, intellectual, moral and industrial, of the next generation of men; the opportunity to be in the general onward and upward movement of the human race, which we must still believe to be in progress, however much we may occasionally be disheartened by revelations of our slow advance—the opportunity to be in this development active and intelligent factors, not mere individuals of the crowd swept on by forces unvalued and unperceived. This great opportunity, and with every great opportunity comes a great duty, the duty of proving equal to the opportunity, is one appealing to the moral as much as to the intellectual side of our nature, and we see at once why it is that the public more or less distinctly classes us teachers with the clergy and requires of us, with reason, much of the same purity and elevation of life which it is accustomed to look for and to find among religious teachers. Indeed, the professions have often been united in the same man, and are still so united. Moreover, with the great decline in mere authority of office, which the religious profession has suffered during the last century, while the teaching profession has had no such loss of prestige, but has, on the contrary, gained immensely in the range and amplitude of means at its disposal—with this condition of things in the world of religious and secular

*Read before the New York Physics Club, March 15, 1902. Slight changes have been made in the paper since the reading.

Correspondence.

QUESTIONS FOR DISCUSSION.

Teachers are invited to send in questions for discussion, as well as answers to the questions of others. Those of sufficient merit and interest will be published.

36. *What is a good list of about a dozen quantitative experiments suitable for a class in high-school chemistry?*

Simple Solution—Chemical Solution—Solubility of Salts—Water of Crystallization—Neutralization—Law of Definite Proportions—Law of Multiple Proportions—Proof that the products of a chemical reaction weigh the same as the factors—The Immunity of manganese dioxide in preparation of oxygen from manganese dioxide and potassium chlorate. These experiments have been successfuly performed in Shortridge High School. See SCHOOL SCIENCE, May, 1901, page 144.

In addition, the following: Weight of a litre of air and of oxygen as given by Dr. Newell's "Experimental Chemistry," also equivalence of zinc, magnesium and aluminum from the same source. Also the weight of a litre of carbon dioxide. See SCHOOL SCIENCE, January, 1902, page 430.

It is not likely that all pupils will have time for all experiments, but each will be able to do some, and listen to the explanations of others.

GEO. W. BENTON.

37. *What cases of chemical arithmetic should a senior class in high school be required to master?*

Second semester pupils in chemistry ought to be able to handle, before the close of the year, the subjects included in such a book as Waddell's "Arithmetic of Chemistry,' up to page 68.

GEO. W. BENTON.

School Science

VOL. II] APRIL, 1902. [No. 2

THE AMERICAN PHYSICS TEACHER'S OPPORTUNITY.*

BY EDWIN H. HALL, PH. D.

Professor of Physics in Harvard University.

This opportunity is first the opportunity of every teacher of youth, the opportunity in some measure to guide, to instruct, to form the leaders, intellectual, moral and industrial, of the next generation of men; the opportunity to be in the general onward and upward movement of the human race, which we must still believe to be in progress, however much we may occasionally be disheartened by revelations of our slow advance—the opportunity to be in this development active and intelligent factors, not mere individuals of the crowd swept on by forces unvalued and unperceived. This great opportunity, and with every great opportunity comes a great duty, the duty of proving equal to the opportunity, is one appealing to the moral as much as to the intellectual side of our nature, and we see at once why it is that the public more or less distinctly classes us teachers with the clergy and requires of us, with reason, much of the same purity and elevation of life which it is accustomed to look for and to find among religious teachers. Indeed, the professions have often been united in the same man, and are still so united. Moreover, with the great decline in mere authority of office, which the religious profession has suffered during the last century, while the teaching profession has had no such loss of prestige, but has, on the contrary, gained immensely in the range and amplitude of means at its disposal—with this condition of things in the world of religious and secular

*Read before the New York Physics Club, March 15, 1902. Slight changes have been made in the paper since the reading.

Correspondence.

QUESTIONS FOR DISCUSSION.

Teachers are invited to send in questions for discussion, as well as answers to the questions of others. Those of sufficient merit and interest will be published.

36. *What is a good list of about a dozen quantitative experiments suitable for a class in high-school chemistry?*

Simple Solution—Chemical Solution—Solubility of Salts—Water of Crystallization—Neutralization—Law of Definite Proportions—Law of Multiple Proportions—Proof that the products of a chemical reaction weigh the same as the factors—The Immunity of manganese dioxide in preparation of oxygen from manganese dioxide and potassium chlorate. These experiments have been successfuly performed in Shortridge High School. See SCHOOL SCIENCE, May, 1901, page 144.

In addition, the following: Weight of a litre of air and of oxygen as given by Dr. Newell's "Experimental Chemistry," also equivalence of zinc, magnesium and aluminum from the same source. Also the weight of a litre of carbon dioxide. See SCHOOL SCIENCE, January, 1902, page 430.

It is not likely that all pupils will have time for all experiments, but each will be able to do some, and listen to the explanations of others.

GEO. W. BENTON.

37. *What cases of chemical arithmetic should a senior class in high school be required to master?*

Second semester pupils in chemistry ought to be able to handle, before the close of the year, the subjects included in such a book as Waddell's "Arithmetic of Chemistry," up to page 68.

GEO. W. BENTON.

School Science

VOL. II] APRIL, 1902. [No. 2

THE AMERICAN PHYSICS TEACHER'S OPPORTUNITY.*

BY EDWIN H. HALL, PH. D.

Professor of Physics in Harvard University.

This opportunity is first the opportunity of every teacher of youth, the opportunity in some measure to guide, to instruct, to form the leaders, intellectual, moral and industrial, of the next generation of men; the opportunity to be in the general onward and upward movement of the human race, which we must still believe to be in progress, however much we may occasionally be disheartened by revelations of our slow advance—the opportunity to be in this development active and intelligent factors, not mere individuals of the crowd swept on by forces unvalued and unperceived. This great opportunity, and with every great opportunity comes a great duty, the duty of proving equal to the opportunity, is one appealing to the moral as much as to the intellectual side of our nature, and we see at once why it is that the public more or less distinctly classes us teachers with the clergy and requires of us, with reason, much of the same purity and elevation of life which it is accustomed to look for and to find among religious teachers. Indeed, the professions have often been united in the same man, and are still so united. Moreover, with the great decline in mere authority of office, which the religious profession has suffered during the last century, while the teaching profession has had no such loss of prestige, but has, on the contrary, gained immensely in the range and amplitude of means at its disposal—with this condition of things in the world of religious and secular

*Read before the New York Physics Club, March 15, 1902. Slight changes have been made in the paper since the reading.

[illegible] can we make [illegible]? If we can do so, we should [illegible] if our object is a power for *good*. [illegible] will certainly be a difficult one, and [illegible] will not come within the next few thousand [illegible], when the heart of the ordinary human being will warm as readily to the study of the impersonal as to the study of the personal. In a recent number of the *New York Nation* there was a long review of a biography of Pasteur. It gave a good account, with considerable technical detail, of the state of knowledge concerning the action

of right-handed and left-handed crystals, of like chemical composition, on plane-polarized light, at the time when Pasteur began the study of such crystals, a study soon attended by brilliant and important discoveries. Now, I feel very sure that most readers of the *Nation* omitted or passed very hastily over this passage, significant as it was; but I feel still more sure that very few who read on to the passage which described Pasteur's controversy with a fellow savant, as to whether a hen can take anthrax, failed to read all that was told on the subject. Pasteur affirmed, in the presence of Colin, that fowls "do not take anthrax." Colin maintained the contrary, and, in response to the challenge of Pasteur, undertook to produce a hen having this disease. He failed, and, finally acknowledging his previous error, declared now that fowls *cannot* take anthrax. Pasteur now affirmed that although fowls *do* not take anthrax under ordinary conditions, they *can be made* to take the disease. This Colin denied; but Pasteur, knowing the normal temperature of a fowl's body to be somewhat too high for the germination of anthrax, cooled a hen in water and then successfully inoculated her with the disease.

I have dwelt somewhat upon this sketch of Pasteur's activities because it has a certain lesson for us, not merely the lesson that a controversy between men is more interesting to the general reader than the solution of an important problem in pure physics, for to dwell much upon this fact might be discouraging, but rather the lesson that it is possible, by means of anecdotes concerning the great men of science, to invest them with a human interest which will be more likely to lead the ordinary student to study their work for the sake of the men than to divert him from a study of the work by undue attention to personalities. I agree entirely with a suggestion recently made by President G. Stanley Hall, that we should make more of the "heroölogy" of science. The general reader who has attained a glimpse of the keen and sportive spirit of Pasteur in the incident of his adversary and the hen will, perhaps, be tempted to turn back to things passed over before and try to understand what such a mind found interesting in crystals and polarized light. Brief biographies of great scientific men are becoming common nowadays, and such books as Cajori's *History of*

Physics are of great assistance. Let us make the most of all such legitimate aids to further our work. But, after all, I cannot look for any very great change, any revolution, of spirit of the average boy toward physics as a result of such a policy on the part of teachers. The simple fact is that, from the point of view of the schoolboy, the great men of science have lived very dull lives. Very few of them ever killed anybody. Their victories were victories of the spirit, impossible to represent by means of the "biograph." Born such a date; died such a date; worked on physics all the time between. On such a day, under such and such conditions, was struck by an idea, from the effects of which he never recovered. That is the way the record will seem to run for most of the great worthies. Such a life is beautiful in its serenity, in its purity, in its elevation, in its ultimate usefulness. It is a happy life; it is a better type of heavenly existence than the eternal playing upon a harp would be for most of us. If we can get boys to feel for one moment the charm of such a life, they will be the better for it all their days. And we can do this for most boys if we really feel the charm ourselves; more surely, if we can exemplify in our own lives a little of what we admire in those of our own great teachers.

But, after all, says plain common sense and common experience, physics carried beyond the mere externals is work, and the average boy is not to be hypnotized into a permanent love for work by gazing at any picture of men who worked because they liked to work. Sooner or later, very soon indeed, we have to face the question whether it is worth while to try to take an ordinary class of boys beyond these pleasing externals.

Occasionally we meet some grave authority whose advice is for the negative of this question; not explicitly, of course; not wittingly, perhaps; very few people ever advise what seems to themselves a superficial treatment of any study. But we find such a man as President G. Stanley Hall saying this:* "The normal boy in the middle teens is often a walking interrogation point about ether, atoms, nature of electricity, X-rays, motors of

*At the meeting of the New England Association of Colleges and Preparatory Schools, Oct. 12, 1901.

many kinds, with a special gravity of mind toward frontier questions where the great masters know as little as he. He would like to see hundreds of demonstrative experiments made in physics and the liberty to repeat most of them himself, without being bothered about mathematics." "He is essentially in the popular science age. He wants great wholes, facts in profusion, and very few formulæ." Now, President Hall is a thoughtful man, a man to be listened to. He speaks in this instance with deliberation and with especial reference to and criticism of the kind of physics teaching which is now common in the schools of New England, the kind of physics teaching which is due in great measure to the efforts of Harvard College to build up in the schools a peculiar system of physics study; a system including as its most original feature a laboratory course of work, mostly quantitative, for performance by pupils. Most of you are doubtless familiar with the general features of this course, which, by the action of the National Educational Association and the Middle States College Admission Board, has now attained a national prominence, and all of you are, I hope, interested in the question, the doubt, or, rather, the criticism and condemnation which President Hall directs toward it. For myself, I welcome this criticism, as I do any intelligent, candid criticism of the system of physics teaching, which I have labored many years to develop and to promote, but which I consider still on trial, still in a state of evolution, still in need of criticism and of suggestion from all who have at heart the great purpose of bringing forth and establishing in American schools the best system of elementary physics teaching that the world can show. To share in this work, by adding to our present practice whatever it needs, by putting out from our present practice which should not be retained, is the great opportunity of the American physics teacher of this generation.

Now, the proposition of President Hall as to what a boy in his middle teens wants, is, in my opinion, all true; but I do not draw from it quite the same conclusion which President Hall draws. Behind his minor proposition, which I do not dispute, there seems to lie in his mind the major proposition that whatever a boy in his middle teens wants he ought to have, and this proposition I

am not prepared to accept. Why is either of these propositions peculiarly true of the middle teens? Boys still younger want "great wholes." Are their desires always safe counselors? Boys or men much older want "great wholes," which they are not willing to work for, which they in some way hope to get without bothering over details. It was only the other day that I received a round-about request from a very wealthy man, who had not found it convenient to go through college, for the name of some book or books that would enable him to get the latest results of physical advance without too much bothering over formulas. The demand for a royal road to knowledge is very old but is still unsatisfied.

But if the argument of President Hall in the passage which I have quoted is not conclusive, his contention may nevertheless be true? If it is unwise to give a boy everything that he desires, it is still more unwise to keep from him everything that he desires. Let us consider the proposed course of study, or instruction, or illumination, or gratification, whatever may be the best name for the experience which President Hall recommends for the boy, on its merits. Granting that the interest of the boy might be maintained through an extended course of such sensations and impressions as President Hall imagines for him, is not our proper inquiry, what would be the state of his mind at the end of the course? What would he really know? What would he be able to do? In what respect would he be more useful to himself or to the world after his experience? Would he have at the end anything more than a broad impression of having seen and heard a great many things, an impression vague, confused, in many respects false, not to be depended on? Somehow, as I try to imagine what the suggested course would be, how it would be managed and how it would result, I think of the nursery, of children eager, importunate, restless, seizing any toy within reach, playing with it a moment, then demanding another; I think of mothers or nurses distracted, of chaos and ennui and utter weariness at the end. It is possibly necessary for children to live this kind of life for a year or two, but must they live it till they reach the "middle teens?" If so, why not longer? When should they begin to have discipline with their mental activities?

But let us take another passage from President Hall's remarks. He says: "But boys of this age want more dynamic physics. Like Maxwell, when a boy, they are interested chiefly in the 'go' of things; those with aptitudes for physics want and need wide acquaintance first with tops, kites, and other physical toys, then with clocks, dynamos, engines, machinery, with some experience in running it and using tools; in looking into, taking apart and putting together almost anything that will go." The word "dynamic," as used in this passage, does not, I take it, have a technical meaning, but only a general significance implying some kind of "go." The whole observation just quoted is sound enough as descriptive of some boys; but it does not follow that it is the proper function of a school course of physics to meet those needs and wants of the boy, which are here set forth. If Maxwell's example teaches us anything for our guidance in this case, it teaches us that the boy "with aptitudes for physics" will pick up such knowledge as that here indicated without school instruction. As I remember the story of his boyhood, he used to go about among workmen asking the "go" and the "particular go" of any, to him, new thing. In these days of countless cheap mechanical toys, must we call on the school to furnish tops, kites and clocks for the boy to experiment with? As to dynamos and engines, the school can reasonably do something. I recommended some years ago three school exercises in the "assembling" of the parts of certain electrical instruments or machinery, and I am glad to see that makers of apparatus now advertise the materials needed for such exercises. But I have never seen my way to go very far in this direction, which soon takes us into the province of manual training rather than of physics proper. Manual training is an excellent discipline. I wish that every boy might have opportunity and encouragement to use the ordinary simplest tools of the wood worker and the metal worker. One of the great advantages of laboratory work in physics is this, that it does give a considerable amount of the same kind of discipline that the workshop gives. But how far can we afford to go in replacing physics by manual training, in minimizing the general and theoretical of our instruction, and magnifying the special and empirical? I may seem disposed to answer

or prejudge this question by the form in which I have put it; but I consider it to be a real and open one, especially for those schools which do not send many boys to college, schools in which the average scholarly ability of the pupils for abstract views and general principles is probably lower* than in the distinctively preparatory schools. This difference of natural endowment has been often ignored in important discussions. It was completely ignored, for example, in the Report of the Committe of Ten. One of the opportunities and the duties of the American physics teacher, recognizing the difference between schools to which I have just alluded, is to work out an answer to the question, still a question in spite of the unanimous opinion of all the conferrees of the Committee of Ten, what differences, if any, there should be in the physics courses of the two great classes of secondary schools. I believe that the necessary differences will not prove to be great. I hope that they will reduce to nothing; but I must at present wait for the verdict of experience. In France, perhaps in Germany, such a question would be settled by the government, by some bureau or some minister. In America we must hammer out the answer by patient labor of individual teachers and by discussion in voluntary assemblies like this one of yours.

But I must return to President Hall, whom I have been neglecting for a few minutes, and I wish now to quote from him one sentence of which I strongly approve. It runs thus: "Moreover, exactness comes relatively late in the development of the youthful mind as it did in that of the race, long after interest in general principles and especially forces." I find some evidence of a desire on the part of school teachers to introduce refinements, or perhaps I should say complications, of apparatus which would be eminently appropriate in a college course on physical measurements, but which are, in my opinion, out of place in the laboratory work of the school. Out of place because they are expensive, troublesome to set up and care for, and, under the conditions prevailing in school work, perhaps even less accurate than the much simpler apparatus which they replace. For example, some teach-

*The reference here is especially to the so called high school or "English High Schools" which many cities maintain side by side with "Latin Schools," the latter receiving nearly all of the pupils who look forward to a college course.

ers have a great dislike for the common spring-balance, and I must admit that, as often put on the market, it is scarcely an instrument of precision. Nevertheless, its quickness of action and the ease with which it is cared for and stored recommend it very strongly for work in which the main emphasis should be on the principle involved in the exercise rather than on the precision of the numerical result. For the use of beginners in determining specific gravity, I had rather, if need be, take the trouble to paste a piece of paper over the inaccurate scale of the spring balance and mark a new and better scale on this paper than provide a scale-pan balance with a set of weights. It is true that in skillful hands the latter will give more precise results, but it will take a longer time. And in the hands of the beginner the result may be no more accurate than that obtained with the spring-balance. The boy who will not, or cannot, with one of the ordinary 250 gm. spring-balances, corrected as to scale, get within 1 gm. of the correct weight of a 100 gm. object, is a boy who would be very likely to abuse a scale-pan balance and miscount or lose the weights. In a later course, when he has gradually become used to the handling of apparatus, he may well determine specific gravities with the scale-pan balance and make correction for the buoyancy of the air; but not at first. Another example: many of you are familiar with an exercise on the bending of wooden bars, in which a simple magnifying index is used as a means of measuring the deflection. The suggestion was lately made to me to replace this crude contrivance by the micrometer-screw and electrical contact method familiar in university laboratories. Now, I confess that students using the lever index often get very bad results; but why? Because they misread the magnifying power of the index, or neglect fractions of millimeters on the scale over which the index passes; in short, because they make simple, boyish blunders and are, some of them, unwilling to take pains. Would they do better with the more complicated and expensive apparatus? I doubt it. A boy who will misread a millimeter scale will miscount the number of turns of a micrometer screw. Moreover, the tables of any ordinary school laboratory, with a class of any considerable size in operation, tremble so much that the delicacy of an elec-

trical contact would be quite thrown away, and the sounder would be in a state of continual chatter during any attempt at a proper setting of the contact screw. Of course, some boys would be interested for a time by the electrical device and might try to make the best use of it; but the kind of interest in physics which can be stimulated only by electrical contrivances is hardly worth rousing at all. It is, no doubt, often the case that the beginner, finding his results inaccurate, is disposed to blame the apparatus and to think either that physics is not the exact science he has always heard it called or that he is not getting the genuine thing. When the teacher finds the boy in this state of mind, he should examine the apparatus and his own conscience, and consider whether the pupil has a real grievance, as he may have. If there is any serious fault of the apparatus which the boy has not been told of; if there is anything treacherous about it, like a screw which ought to be tight and is not, or a weight which is incorrectly marked, the teacher should spare no reasonable pains to make the thing right for the future. But if it appears, as it often will appear, that the trouble all lies in the fact that the boy has been, quite unconsciously perhaps, blundering and shirking, then it is the teacher's opportunity to impress upon the mind of that boy, kindly and sympathetically, but unmistakably, the truth that physics is not a science or an art by means of which blindness and laziness escape their natural consequences, but rather a field of experience in which these qualities are overtaken, with peculiar certainty, by their legitimate but unwelcome offspring. For though it is a mistake to make accuracy of performance the foremost consideration in elementary work, the pupil will himself find something lacking in his discipline and grow dissatisfied if he is not held to a conscious effort toward such accuracy as the apparatus at command will fairly yield.

There is one other particular in which, I fear, some teachers of my acquaintance are making a mistake, namely, the comparative neglect of qualitative experiments at the lecture table. I feel called upon to protest so often against what I believe to be the great wastefulness of qualitative laboratory courses for school pupils that I am in some danger of being misunderstood and

being quoted in opposition to qualitative experiments generally. The fact is that I attach very great importance to such experiments in what I believe to be their proper place, the lecture-room, and I take great pains with such experiments. I suppose that some teachers think they have not time for such work, feeling, perhaps, that they must bend all their efforts to the accomplishment of those things which appear prominently in examinations for admission to college. It is quite possible that we who conduct such examinations ought to change our practices of interrogation somewhat and try to make a knowledge of qualitative experiments more important in our tests. I am satisfied that real economy of effort in teaching as well as in learning requires much attention to such experiments. For example, it is a great mistake to undertake to teach Ohm's law without first giving an exhibition of the electromotive force of a battery in open circuit by means of the condensing electroscope. No voltmeter which looks to the pupil just like an ammeter and is, in fact, dependent on *current* for its action, will serve the purpose of initial enlightenment; it will rather deepen confusion. Of course, pupils can be trained to a mechanical facility in the use of Ohm's law without having any satisfactory sense of the nature of the factors involved; but such formalism is not what we hope to get from physics.

I made it plain in the first part of this address that I do not expect to see physics become a popular favorite among school studies. It must remain a rather severe study, when thoroughly treated, and perhaps, on the whole, its necessary severity is not to be regretted. If we can get boys to follow a good, stiff course of it to the end in school, with a measure of cheerfulness on their part, feeling that they are getting wholesome discipline and useful information, we need not be greatly disturbed if most of them do not pursue the formal study of it afterward. Let us not think it our duty to proselyte to the life-long prosecution of this science those who have no especial aptitude for it. But, on the other hand, let us not forget that the abolition of unnecessary difficulty, the economy and the attractiveness of efficient methods of presentation and work, are ends to be constantly sought by every

trical contact would be quite thrown away, and the sounder would be in a state of continual chatter during any attempt at a proper setting of the contact screw. Of course, some boys would be interested for a time by the electrical device and might try to make the best use of it; but the kind of interest in physics which can be stimulated only by electrical contrivances is hardly worth rousing at all. It is, no doubt, often the case that the beginner, finding his results inaccurate, is disposed to blame the apparatus and to think either that physics is not the exact science he has always heard it called or that he is not getting the genuine thing. When the teacher finds the boy in this state of mind, he should examine the apparatus and his own conscience, and consider whether the pupil has a real grievance, as he may have. If there is any serious fault of the apparatus which the boy has not been told of; if there is anything treacherous about it, like a screw which ought to be tight and is not, or a weight which is incorrectly marked, the teacher should spare no reasonable pains to make the thing right for the future. But if it appears, as it often will appear, that the trouble all lies in the fact that the boy has been, quite unconsciously perhaps, blundering and shirking, then it is the teacher's opportunity to impress upon the mind of that boy, kindly and sympathetically, but unmistakably, the truth that physics is not a science or an art by means of which blindness and laziness escape their natural consequences, but rather a field of experience in which these qualities are overtaken, with peculiar certainty, by their legitimate but unwelcome offspring. For though it is a mistake to make accuracy of performance the foremost consideration in elementary work, the pupil will himself find something lacking in his discipline and grow dissatisfied if he is not held to a conscious effort toward such accuracy as the apparatus at command will fairly yield.

There is one other particular in which, I fear, some teachers of my acquaintance are making a mistake, namely, the comparative neglect of qualitative experiments at the lecture table. I feel called upon to protest so often against what I believe to be the great wastefulness of qualitative laboratory courses for school pupils that I am in some danger of being misunderstood and

being quoted in opposition to qualitative experiments generally. The fact is that I attach very great importance to such experiments in what I believe to be their proper place, the lecture-room, and I take great pains with such experiments. I suppose that some teachers think they have not time for such work, feeling, perhaps, that they must bend all their efforts to the accomplishment of those things which appear prominently in examinations for admission to college. It is quite possible that we who conduct such examinations ought to change our practices of interrogation somewhat and try to make a knowledge of qualitative experiments more important in our tests. I am satisfied that real economy of effort in teaching as well as in learning requires much attention to such experiments. For example, it is a great mistake to undertake to teach Ohm's law without first giving an exhibition of the electromotive force of a battery in open circuit by means of the condensing electroscope. No voltmeter which looks to the pupil just like an ammeter and is, in fact, dependent on *current* for its action, will serve the purpose of initial enlightenment; it will rather deepen confusion. Of course, pupils can be trained to a mechanical facility in the use of Ohm's law without having any satisfactory sense of the nature of the factors involved; but such formalism is not what we hope to get from physics.

I made it plain in the first part of [illegible] that I do not expect to see physics become a popular [illegible] among school studies. It must remain a rather severe [illegible] when thoroughly treated, and perhaps, on the whole, its [illegible] not to be regretted. If we can get boys to follow a [illegible] course of it to the end in school, with a measure of [illegible] on their part, feeling that they are getting wholesome [illegible] and useful information, we need not be greatly [illegible] most of them do not pursue the formal study of [illegible] let us not think it our duty to preclude us the [illegible] tion of this science those who have no especial [illegible]. But, on the other hand, let us not forget that the [illegible] unnecessary difficulty, the economy and the attractiveness [illegible] our methods of presentation and work, are [illegible] very

reasonable effort of the teacher. As compared with the teaching of the classics and the teaching of mathematics, the teaching of physics, especially by the method we are following, is a new art. Often a teacher will find that a slight variation of form in the statement of a proposition or the description of an experiment will make all the difference between success and failure. Every year I find my copy of the laboratory manual used by my lowest class scarred with new inscriptions put down under the stimulus and inspiration of new experience with old problems, and when this ceases to be the case I shall suspect that I am getting too old to teach. Regard for form, not only of thought and of work, but also of personal carriage and of speech is a duty of every teacher, and perhaps teachers of science, with their minds occupied to the full by the matter of a robust and growing body of knowledge, are somewhat less regardful of this duty than teachers of other things, the classics for example.

In the development and perfecting of himself as a teacher, the school man will find scope enough for his energies. It is not enough for him to know his text book or his laboratory manual. Writers of text books and of manuals sometimes err, and the teacher must be able to make correction. Books of a few years back get out of date. The newspapers and magazines are constantly filled with strange stories, sometimes true and sometimes not, of wonderful things done or to be done in science. The teachers should read, and read intelligently, with an open mind watched over by an enlightened skepticism. He should know, too, who are the writers to be depended on and where their opinions are to be found. If the school teacher of physics, regarding himself as one of a great body enlisted in the noble purpose of making the teaching of physics of the greatest possible good to the youth of our land and ultimately to the youth of the world, does all the things which have been suggested in this paper, will he have time for what is commonly called original research? Regretting, as I must, to differ in opinion from my friend Professor Nichols in regard to this matter, I must answer, no. Much as I admire the suggestiveness of Professor Nichols' address, delivered, I think, before this club, I can hardly believe that one

teacher in fifty will find it practicable to carry out even the least formidable of his proposed investigations. Original research, successful and profitable original research, requires rare qualities of combined enterprise, insight and patience, and an atmosphere different from that of the school. It requires specialization, absorption in the enthusiasm of the pursuit for what, in the end, will probably attract the attention of very few. "Does any one read your articles?", a distinguished chemist asked me a few years ago, "I don't think anybody ever reads mine." The joy of research is mainly in the doing, and this joy is for comparatively few minds. The same kind of joy, and perhaps quite as wide a fame, may come to one by the mere exercise of his energy and inventiveness in the perfecting of devices for successful laboratory work. The thrill which comes to a man who, after many fruitless efforts, has made a label stick where it would never stick before, is not so very different in kind from that of the man who has carried some research to a successful conclusion.

But what of "duty to science" and high ideals generally? Prof. Ladd, of Yale, is right when he says in a recent number of *The Forum,* using words which I cannot now exactly recall, that no one owes a "duty to science," that duty is to mankind. Some men, says Professor Ladd, can best serve mankind by following out their instincts and exercising their talents for high research; but others can serve best in other ways. If the school teacher has the real fever for research in his veins, a mad passion for squandering months and years in the endeavor to find out something about, let us say, the thermal conductivity of metals or the resistance of galvanic cells, by all means let him give his passion free swing, provided he can do so without neglecting his primary duties. His labors will probably be, to use the happy phrase which the barber who lavished his professional zeal on me this morning applied to his own handiwork, "genteel, harmless and not too conspicuous." That, at least, is what I find to be true of the majority of my own efforts at original research. But let no school teacher feel that his profession requires him to do this kind of work. He will be most happy, most useful and most respected in doing zealously the thing he can do best.

CHEMISTRY IN EDUCATION.

BY C. L. SPEYERS.

Professor of Chemistry in Rutgers College.

I shall define the art of education as the art of showing how to find in outside Nature, in the external world, that which satisfies the demands of our inner nature, both physical and mental. The word is used in many ways I think; I shall use it in this way. The more educated a man is, the more numerous are his demands and the more numerous are the means for satisfying them.

I cannot go into even a few of these different demands, much less all of them—time forbids that—but I can touch on one demand of an educated mind, namely, to know what the universe is made of, why does it behave as it does, what is its destiny? In so far as these questions refer to matter and energy, they are to find their answers in chemistry. As yet, in a very modest way, we do not know what this earth is made of, let alone another planet; we do not seem to know what the air even is made of. Nevertheless I would claim on account of what has already been done that these questions will in time find their answers in discoveries and theories properly belonging to chemistry, though perhaps in the far future when the answers come, what we now call chemistry will be then called something quite different, perhaps electricity, and the chemist an electrician.

It becomes us therefore to treat chemistry as a very important factor in education for next in importance to the question of what is the destiny of man, and preceding this question as the foundations to it, are the above ones comprising the composition and destiny of the material universe.

I would begin the study of chemistry at an early age, not in a book way, nor in a laborious way, but in a simple, homely manner, with the experiences of domestic life, and in a form of serious play, not in a form of a real study. I would begin with the little understood but very important operations of cooking. It is curious how little we know about the science of preparing food, but yet we know enough about it to make it a proper introduction to chemistry for

children. And I would include both sexes in this part of the subject. Why not? Proper food and a knowledge of it is as important to man as to woman. At 10 years I should say would be a good age to begin; trial would show whether that was too early or not early enough.

Bread baking would be a good subject to begin with. Quite a number of interesting things can hereby be brought out. How flour and water alone make a poor, unpalatable food; how a gluey consistency on the one hand and a hard, stony nature on the other must be avoided. Judicious questioning will lead the pupils to suggest a way of making the bread puffy by use of some gas. Questioning should play a most important part in education, through the whole course of education, in the college as well as in the school, because scientific investigation in general is but a series of questions put to Nature, and it is exceedingly important that the pupil and student should be shown how to put good questions to nature by having good questions put to him. Then as to where the gas is to be obtained, which will finally lead into baking powders and into yeasts, showing the formation of a gas. In this way the children gradually come to see how intricate and interesting such a homely operation as bread baking is. Experiments should of course accompany these descriptions and as with gas stoves there is nothing dangerous, the children can make the experiments themselves, of course under the supervision of the teacher. Then should come a little historical sketch of bread making and a statement of how long it was before the true nature of bread raising became known, and how long it was before baking powders were invented. A comparison between the healthfulness of yeast products and baking powder products should be drawn. Likewise a short description of flour making is to be given and the different constituents of flour shown, the gluten and the starch, and how the latter changes into glucose.

Then some other domestic operation is to be taken up, say candy making. The making of candy can become a very interesting study in crystallography. The making of the so-called "fondant," a very finely crystallized sugar; and barley sugar and rock candy,—all involve very interesting facts. Together with candy making

can go a short description of the getting of sugar from sugar cane, and the occurrence of sugar in the beet root in abundance, and in other roots in smaller quantities. Then the relation that cane sugar bears to glucose, that this bears to plant nutrition, and the statement that though the chemist can change cane sugar into glucose, the reverse change cannot yet be made by him.

Let the cooking of meat and vegetables follow the different effect of cooking in water or boiling, and cooking in fat or frying can be pointed out, and the difference between boiling, frying, and broiling made clear. A consideration of the liquid coming from boiled meat leads into soups and meat extracts. The small nourishing power of soups and ordinary meat extracts should be pointed out. A comparison would likewise be desirable between animal gelatin and fruit gelatin, animal jellies and fruit jellies, the animal gelatin containing nitrogen, the fruit gelatin containing none; and so on with other forms of food.

In the spring time the subject of plant chemistry can be properly taken up. Let this begin with the seed in sterile sand. Then, by adding the proper ingredients and the improper ones, the child can find out what makes food for plants and what does not. Such experiments could not be made with animals without injuring the child's sensibilities in a serious way. The great difference between the food for plants and the food for animals should be carefully pointed out.

Then, operations connected with building, like the making of mortar and cement, and painting, can all be made very useful in cultivating the reasoning and observational powers of the children.

Clothing should also be considered. The making of textile fabrics from cotton and from wool; the difference between cotton and wool physically and chemically, in relation to dyes. The subject of dyeing could also be introduced in an elementary way, and the difference between dyeing and painting pointed out.

How much time should be spent upon such a course will depend upon the interest of the pupils and resources of the school, but the course should be so arranged that when finished the pupil is old enough to perceive that the substances hitherto used are so complicated that it is impossible to get a true insight into what

happens by the consideration of such complex things; that we can hope to get our ideas properly directed only by the consideration of simple things, but when so properly directed, then the complicated cases will at once open out into a collection of simple cases; that the preceding cases were intended to arouse his interest in a kindergarten way, and that although he came to learn valuable things, yet the more immediate object was to arouse his interest about the true inwardness of things, so that he would be glad to spend a good deal of time in drudgery, so as to reach at last the proper way to advance the knowledge of the human race, either directly by his own researches, or indirectly by aiding others to do so.

He is then ready to proceed to the scientific study of chemistry. The study can follow two lines; either the historic line, or that line which experience has shown to be the simplest, and leading directly to the desired result. For advanced students who fairly understand a subject, the historical study of this subject is of the utmost importance, for only in this way can they come to understand how great experimental difficulties are to be overcome, proper explanations reached, the subject put into an organized form, and so prepare themselves to carry on successful investigation. But I do not see how the student can understand the difficulties of pioneer investigation and the ingenuity displayed in overcoming these difficulties until he has made a fairly good survey of the whole science and is at home in it. Accordingly, I prefer to introduce the historical study of chemistry, and I speak only for chemistry, near the end of the course, not anywhere near the beginning of it, and as a preparation for investigation. And so I would take the other way, the shortest way, for beginners.

Should physics precede chemistry, or should chemistry precede physics? This question can easily be answered for an ideal chemical course, because the time has passed when the science of chemistry can be taught without previous knowledge of physics. We cannot interpret chemical changes any longer without calling upon those methods of experiment and those notions which are commonly studied under the head of physics. But the physicist need not study chemistry to get a large, comprehensive idea of physics. Chemistry is, of course, very desirable for an educated physicist;

he must have a good knowledge of it, but not nearly to the same extent that a chemist must of physics. So that I should claim, as a preliminary to a good chemical course, a thorough training in physics. Not, perhaps, finishing physics before beginning chemistry, but keeping the physical studies far beyond the chemical ones. This is more difficult to do because the school training in physics involves a considerable outlay in money for apparatus, much more than the chemical training does, and many schools cannot afford good physical courses, and so a student enters college with a training in physics inferior to the training in chemistry. Those parts of physics which involve chemical changes, such as galvanic electricity, photography, spectroscopy, can be considered under physical chemistry in the chemical courses.

It seems to me that the only objection the physicist can make to this arrangement is the immaturity of the student. He may claim that physics is so much harder than chemistry that a more mature mind is needed for it. But is physics so much harder? Physical phenomena are in general capable of very exact expression and description, so that mathematical formulæ can be readily applied to them, and in consequence these phenomena are well organized and expressed in simple terms. This is not the case in chemistry. Even in organic chemistry, we are far from being able to express relations simply, and even in inorganic chemistry the only organization that we have is expressed in the periodic law which again is only a collection of some empirical rules. We find in general that the less organized a subject is, the more trained the intellect must be which masters it. And so everything seems to me to favor putting physics before chemistry, as much as possible before it. In many colleges, however, the two sciences have to run side by side, and the teacher of chemistry must get along the best way that he can.

Should we begin with analytical chemistry or with phenomenal chemistry or general chemistry, as the latter is frequently called? Should we begin by teaching how to recognize substances or should we begin by considering the properties of substances without special reference to their detection?

Both ways have advantages. The older way was to begin

with analytical chemistry. When we do this, we plunge the student at once into a subject whose theory he cannot understand at the beginning, and so has to work at the subject as an art, not as a science. At the same time, analytical chemistry is an excellent disciplinary subject, and with large classes in a laboratory perhaps better work can be done with that branch than with any other, but only when the classes are large, so large that the instructor cannot give individual attention to the student for more than a few minutes at a time. Such a condition of affairs should not exist in college or university; the teaching force should be large enough to give one instructor to not more than 25 students, but this is not always possible. With explanatory lectures, good note books, and quizzes, a large class can be given a good knowledge of the art of qualitative analysis and incidentally some knowledge of experimental, inorganic chemistry and, considering the course as a whole, this arrangement will not be so bad. Class room work in the form of lectures on general chemistry should begin at the outset of the course, whether analytical chemistry precede general chemistry in the laboratory or not.

(*Concluded in May*)

THE PLANTING OF CHEMISTRY IN AMERICA.

BY RUFUS PHILLIPS WILLIAMS.

There were half a dozen centers for the early dissemination of chemical knowledge in this country. The first planting of the science on our shores was in connection with anatomy and materia medica, and but for medical schools, chemistry teaching would have been delayed for many a decade. Down to the year 1765, there was not a school of medicine on the American continent, and all physicians must necessarily study in Europe where the profession had been recognized for some 2,200 years, and where medical professors still gave their lectures in the Latin language. The honor of establishing the first such school here belongs to Philadelphia. This was natural, for during the last half of the

trical contact would be quite thrown away, and the sounder would be in a state of continual chatter during any attempt at a proper setting of the contact screw. Of course, some boys would be interested for a time by the electrical device and might try to make the best use of it; but the kind of interest in physics which can be stimulated only by electrical contrivances is hardly worth rousing at all. It is, no doubt, often the case that the beginner, finding his results inaccurate, is disposed to blame the apparatus and to think either that physics is not the exact science he has always heard it called or that he is not getting the genuine thing. When the teacher finds the boy in this state of mind, he should examine the apparatus and his own conscience, and consider whether the pupil has a real grievance, as he may have. If there is any serious fault of the apparatus which the boy has not been told of; if there is anything treacherous about it, like a screw which ought to be tight and is not, or a weight which is incorrectly marked, the teacher should spare no reasonable pains to make the thing right for the future. But if it appears, as it often will appear, that the trouble all lies in the fact that the boy has been, quite unconsciously perhaps, blundering and shirking, then it is the teacher's opportunity to impress upon the mind of that boy, kindly and sympathetically, but unmistakably, the truth that physics is not a science or an art by means of which blindness and laziness escape their natural consequences, but rather a field of experience in which these qualities are overtaken, with peculiar certainty, by their legitimate but unwelcome offspring. For though it is a mistake to make accuracy of performance the foremost consideration in elementary work, the pupil will himself find something lacking in his discipline and grow dissatisfied if he is not held to a conscious effort toward such accuracy as the apparatus at command will fairly yield.

There is one other particular in which, I fear, some teachers of my acquaintance are making a mistake, namely, the comparative neglect of qualitative experiments at the lecture table. I feel called upon to protest so often against what I believe to be the great wastefulness of qualitative laboratory courses for school pupils that I am in some danger of being misunderstood and

being quoted in opposition to qualitative experiments generally. The fact is that I attach very great importance to such experiments in what I believe to be their proper place, the lecture-room, and I take great pains with such experiments. I suppose that some teachers think they have not time for such work, feeling, perhaps, that they must bend all their efforts to the accomplishment of those things which appear prominently in examinations for admission to college. It is quite possible that we who conduct such examinations ought to change our practices of interrogation somewhat and try to make a knowledge of qualitative experiments more important in our tests. I am satisfied that real economy of effort in teaching as well as in learning requires much attention to such experiments. For example, it is a great mistake to undertake to teach Ohm's law without first giving an exhibition of the electromotive force of a battery in open circuit by means of the condensing electroscope. No voltmeter which looks to the pupil just like an ammeter and is, in fact, dependent on *current* for its action, will serve the purpose of initial enlightenment; it will rather deepen confusion. Of course, pupils can be trained to a mechanical facility in the use of Ohm's law without having any satisfactory sense of the nature of the factors involved; but such formalism is not what we hope to get from physics.

I made it plain in the first part of this address that I do not expect to see physics become a popular favorite among school studies. It must remain a rather severe study, when thoroughly treated, and perhaps, on the whole, its necessary severity is not to be regretted. If we can get boys to follow a good, stiff course of it to the end in school, with a measure of cheerfulness on their part, feeling that they are getting wholesome discipline and useful information, we need not be greatly disturbed if most of them do not pursue the formal study of it afterward. Let us not think it our duty to proselyte to the life-long prosecution of this science those who have no especial aptitude for it. But, on the other hand, let us not forget that the abolition of unnecessary difficulty, the economy and the attractiveness of efficient methods of presentation and work, are ends to be constantly sought by every

reasonable effort of the teacher. As compared with the teaching of the classics and the teaching of mathematics, the teaching of physics, especially by the method we are following, is a new art. Often a teacher will find that a slight variation of form in the statement of a proposition or the description of an experiment will make all the difference between success and failure. Every year I find my copy of the laboratory manual used by my lowest class scarred with new inscriptions put down under the stimulus and inspiration of new experience with old problems, and when this ceases to be the case I shall suspect that I am getting too old to teach. Regard for form, not only of thought and of work, but also of personal carriage and of speech is a duty of every teacher, and perhaps teachers of science, with their minds occupied to the full by the matter of a robust and growing body of knowledge, are somewhat less regardful of this duty than teachers of other things, the classics for example.

In the development and perfecting of himself as a teacher, the school man will find scope enough for his energies. It is not enough for him to know his text book or his laboratory manual. Writers of text books and of manuals sometimes err, and the teacher must be able to make correction. Books of a few years back get out of date. The newspapers and magazines are constantly filled with strange stories, sometimes true and sometimes not, of wonderful things done or to be done in science. The teachers should read, and read intelligently, with an open mind watched over by an enlightened skepticism. He should know, too, who are the writers to be depended on and where their opinions are to be found. If the school teacher of physics, regarding himself as one of a great body enlisted in the noble purpose of making the teaching of physics of the greatest possible good to the youth of our land and ultimately to the youth of the world, does all the things which have been suggested in this paper, will he have time for what is commonly called original research? Regretting, as I must, to differ in opinion from my friend Professor Nichols in regard to this matter, I must answer, no. Much as I admire the suggestiveness of Professor Nichols' address, delivered, I think, before this club, I can hardly believe that one

teacher in fifty will find it practicable to carry out even the least formidable of his proposed investigations. Original research, successful and profitable original research, requires rare qualities of combined enterprise, insight and patience, and an atmosphere different from that of the school. It requires specialization, absorption in the enthusiasm of the pursuit for what, in the end, will probably attract the attention of very few. "Does any one read your articles?", a distinguished chemist asked me a few years ago, "I don't think anybody ever reads mine." The joy of research is mainly in the doing, and this joy is for comparatively few minds. The same kind of joy, and perhaps quite as wide a fame, may come to one by the mere exercise of his energy and inventiveness in the perfecting of devices for successful laboratory work. The thrill which comes to a man who, after many fruitless efforts, has made a label stick where it would never stick before, is not so very different in kind from that of the man who has carried some research to a successful conclusion.

But what of "duty to science" and high ideals generally? Prof. Ladd, of Yale, is right when he says in a recent number of *The Forum,* using words which I cannot now exactly recall, that no one owes a "duty to science," that duty is to mankind. Some men, says Professor Ladd, can best serve mankind by following out their instincts and exercising their talents for high research; but others can serve best in other ways. If the school teacher has the real fever for research in his veins, a mad passion for squandering months and years in the endeavor to find out something about, let us say, the thermal conductivity of metals or the resistance of galvanic cells, by all means let him give his passion free swing, provided he can do so without neglecting his primary duties. His labors will probably be, to use the happy phrase which the barber who lavished his professional zeal on me this morning applied to his own handiwork, "genteel, harmless and not too conspicuous." That, at least, is what I find to be true of the majority of my own efforts at original research. But let no school teacher feel that his profession requires him to do this kind of work. He will be most happy, most useful and most respected in doing zealously the thing he can do best.

CHEMISTRY IN EDUCATION.

BY C. L. SPEYERS.

Professor of Chemistry in Rutgers College.

I shall define the art of education as the art of showing how to find in outside Nature, in the external world, that which satisfies the demands of our inner nature, both physical and mental. The word is used in many ways I think; I shall use it in this way. The more educated a man is, the more numerous are his demands and the more numerous are the means for satisfying them.

I cannot go into even a few of these different demands, much less all of them—time forbids that—but I can touch on one demand of an educated mind, namely, to know what the universe is made of, why does it behave as it does, what is its destiny? In so far as these questions refer to matter and energy, they are to find their answers in chemistry. As yet, in a very modest way, we do not know what this earth is made of, let alone another planet; we do not seem to know what the air even is made of. Nevertheless I would claim on account of what has already been done that these questions will in time find their answers in discoveries and theories properly belonging to chemistry, though perhaps in the far future when the answers come, what we now call chemistry will be then called something quite different, perhaps electricity, and the chemist an electrician.

It becomes us therefore to treat chemistry as a very important factor in education for next in importance to the question of what is the destiny of man, and preceding this question as the foundations to it, are the above ones comprising the composition and destiny of the material universe.

I would begin the study of chemistry at an early age, not in a book way, nor in a laborious way, but in a simple, homely manner, with the experiences of domestic life, and in a form of serious play, not in a form of a real study. I would begin with the little understood but very important operations of cooking. It is curious how little we know about the science of preparing food, but yet we know enough about it to make it a proper introduction to chemistry for

children. And I would include both sexes in this part of the subject. Why not? Proper food and a knowledge of it is as important to man as to woman. At 10 years I should say would be a good age to begin; trial would show whether that was too early or not early enough.

Bread baking would be a good subject to begin with. Quite a number of interesting things can hereby be brought out. How flour and water alone make a poor, unpalatable food; how a gluey consistency on the one hand and a hard, stony nature on the other must be avoided. Judicious questioning will lead the pupils to suggest a way of making the bread puffy by use of some gas. Questioning should play a most important part in education, through the whole course of education, in the college as well as in the school, because scientific investigation in general is but a series of questions put to Nature, and it is exceedingly important that the pupil and student should be shown how to put good questions to nature by having good questions put to him. Then as to where the gas is to be obtained, which will finally lead into baking powders and into yeasts, showing the formation of a gas. In this way the children gradually come to see how intricate and interesting such a homely operation as bread baking is. Experiments should of course accompany these descriptions and as with gas stoves there is nothing dangerous, the children can make the experiments themselves, of course under the supervision of the teacher. Then should come a little historical sketch of bread making and a statement of how long it was before the true nature of bread raising became known, and how long it was before baking powders were invented. A comparison between the healthfulness of yeast products and baking powder products should be drawn. Likewise a short description of flour making is to be given and the different constituents of flour shown, the gluten and the starch, and how the latter changes into glucose.

Then some other domestic operation is to be taken up, say candy making. The making of candy can become a very interesting study in crystallography. The making of the so-called "fondant," a very finely crystallized sugar; and barley sugar and rock candy,—all involve very interesting facts. Together with candy making

can go a short description of the getting of sugar from sugar cane, and the occurrence of sugar in the beet root in abundance, and in other roots in smaller quantities. Then the relation that cane sugar bears to glucose, that this bears to plant nutrition, and the statement that though the chemist can change cane sugar into glucose, the reverse change cannot yet be made by him.

Let the cooking of meat and vegetables follow the different effect of cooking in water or boiling, and cooking in fat or frying can be pointed out, and the difference between boiling, frying, and broiling made clear. A consideration of the liquid coming from boiled meat leads into soups and meat extracts. The small nourishing power of soups and ordinary meat extracts should be pointed out. A comparison would likewise be desirable between animal gelatin and fruit gelatin, animal jellies and fruit jellies, the animal gelatin containing nitrogen, the fruit gelatin containing none; and so on with other forms of food.

In the spring time the subject of plant chemistry can be properly taken up. Let this begin with the seed in sterile sand. Then, by adding the proper ingredients and the improper ones, the child can find out what makes food for plants and what does not. Such experiments could not be made with animals without injuring the child's sensibilities in a serious way. The great difference between the food for plants and the food for animals should be carefully pointed out.

Then, operations connected with building, like the making of mortar and cement, and painting, can all be made very useful in cultivating the reasoning and observational powers of the children.

Clothing should also be considered. The making of textile fabrics from cotton and from wool; the difference between cotton and wool physically and chemically, in relation to dyes. The subject of dyeing could also be introduced in an elementary way, and the difference between dyeing and painting pointed out.

How much time should be spent upon such a course will depend upon the interest of the pupils and resources of the school, but the course should be so arranged that when finished the pupil is old enough to perceive that the substances hitherto used are so complicated that it is impossible to get a true insight into what

happens by the consideration of such complex things; that we can hope to get our ideas properly directed only by the consideration of simple things, but when so properly directed, then the complicated cases will at once open out into a collection of simple cases; that the preceding cases were intended to arouse his interest in a kindergarten way, and that although he came to learn valuable things, yet the more immediate object was to arouse his interest about the true inwardness of things, so that he would be glad to spend a good deal of time in drudgery, so as to reach at last the proper way to advance the knowledge of the human race, either directly by his own researches, or indirectly by aiding others to do so.

He is then ready to proceed to the scientific study of chemistry. The study can follow two lines; either the historic line, or that line which experience has shown to be the simplest, and leading directly to the desired result. For advanced students who fairly understand a subject, the historical study of this subject is of the utmost importance, for only in this way can they come to understand how great experimental difficulties are to be overcome, proper explanations reached, the subject put into an organized form, and so prepare themselves to carry on successful investigation. But I do not see how the student can understand the difficulties of pioneer investigation and the ingenuity displayed in overcoming these difficulties until he has made a fairly good survey of the whole science and is at home in it. Accordingly, I prefer to introduce the historical study of chemistry, and I speak only for chemistry, near the end of the course, not anywhere near the beginning of it, and as a preparation for investigation. And so I would take the other way, the shortest way, for beginners.

Should physics precede chemistry, or should chemistry precede physics? This question can easily be answered for an ideal chemical course, because the time has passed when the science of chemistry can be taught without previous knowledge of physics. We cannot interpret chemical changes any longer without calling upon those methods of experiment and those notions which are commonly studied under the head of physics. But the physicist need not study chemistry to get a large, comprehensive idea of physics. Chemistry is, of course, very desirable for an educated physicist;

he must have a good knowledge of it, but not nearly to the same extent that a chemist must of physics. So that I should claim, as a preliminary to a good chemical course, a thorough training in physics. Not, perhaps, finishing physics before beginning chemistry, but keeping the physical studies far beyond the chemical ones. This is more difficult to do because the school training in physics involves a considerable outlay in money for apparatus, much more than the chemical training does, and many schools cannot afford good physical courses, and so a student enters college with a training in physics inferior to the training in chemistry. Those parts of physics which involve chemical changes, such as galvanic electricity, photography, spectroscopy, can be considered under physical chemistry in the chemical courses.

It seems to me that the only objection the physicist can make to this arrangement is the immaturity of the student. He may claim that physics is so much harder than chemistry that a more mature mind is needed for it. But is physics so much harder? Physical phenomena are in general capable of very exact expression and description, so that mathematical formulæ can be readily applied to them, and in consequence these phenomena are well organized and expressed in simple terms. This is not the case in chemistry. Even in organic chemistry, we are far from being able to express relations simply, and even in inorganic chemistry the only organization that we have is expressed in the periodic law which again is only a collection of some empirical rules. We find in general that the less organized a subject is, the more trained the intellect must be which masters it. And so everything seems to me to favor putting physics before chemistry, as much as possible before it. In many colleges, however, the two sciences have to run side by side, and the teacher of chemistry must get along the best way that he can.

Should we begin with analytical chemistry or with phenomenal chemistry or general chemistry, as the latter is frequently called? Should we begin by teaching how to recognize substances or should we begin by considering the properties of substances without special reference to their detection?

Both ways have advantages. The older way was to begin

with analytical chemistry. When we do this, we plunge the student at once into a subject whose theory he cannot understand at the beginning, and so has to work at the subject as an art, not as a science. At the same time, analytical chemistry is an excellent disciplinary subject, and with large classes in a laboratory perhaps better work can be done with that branch than with any other, but only when the classes are large, so large that the instructor cannot give individual attention to the student for more than a few minutes at a time. Such a condition of affairs should not exist in college or university; the teaching force should be large enough to give one instructor to not more than 25 students, but this is not always possible. With explanatory lectures, good note books, and quizzes, a large class can be given a good knowledge of the art of qualitative analysis and incidentally some knowledge of experimental, inorganic chemistry and, considering the course as a whole, this arrangement will not be so bad. Class room work in the form of lectures on general chemistry should begin at the outset of the course, whether analytical chemistry precede general chemistry in the laboratory or not.

(*Concluded in May*)

THE PLANTING OF CHEMISTRY IN AMERICA.

BY RUFUS PHILLIPS WILLIAMS.

There were half a dozen centers for the early dissemination of chemical knowledge in this country. The first planting of the science on our shores was in connection with anatomy and materia medica, and but for medical schools, chemistry teaching would have been delayed for many a decade. Down to the year 1765, there was not a school of medicine on the American continent, and all physicians must necessarily study in Europe where the profession had been recognized for some 2,200 years, and where medical professors still gave their lectures in the Latin language. The honor of establishing the first such school here belongs to Philadelphia. This was natural, for during the last half of the

18th century, and for many years afterwards, the Quaker City was the Mecca of science as well as of literature. Here the first scientific society in America—The American Philosophical Society—was established in 1766, with Benjamin Franklin as president. A similar organization, due to the efforts of John Adams, was founded in Boston fourteen years later. This was the "American Academy of Arts and Sciences." It may be mentioned that the only foundations for science work in the Republic when Washington became President were the two societies named above, one natural history museum, one botanic garden and one private astronomical observatory. The first patent under the new government was for a chemical process, to make "pot and pearl ashes," granted to Samuel Hopkins of Vermont, in July, 1790.

Backward as science seems to have been, it was perhaps not much more so than other subjects. Charles Kendall Adams says that it was "nearly two centuries after the founding of Harvard College before the study of history in that institution had any standing whatever. It was not till 1839 that the study of history in any American college was first encouraged by the endowment of a special chair." Harvard had that first chair and Jared Spark occupied it.

New York.

Though Philadelphia was the home of the earliest medical school, the first professorship in chemistry appears to have been created in New York in 1767. Previous to this, some little instruction in medicine had been given to young men; the earliest recorded lectures being by Dr. John Bard and Peter Middleton in New York City. However, the first attempt to organize a medical school there was in 1767, and August 14 of that year one Dr. James Smith, brother of William Smith, the historian, was appointed professor of chemistry and materia medica, teachers in other branches being also chosen at the same time. The school was not opened till the following year, when it was placed under the direction of the College of the Province of New York, but was broken up by the Revolution and not reörganized till 1792. Smith's term of service began in 1768 and ended in 1770, but his distinction is that of being the first regularly appointed pro-

fessor of chemistry in America. The reörganized institution was called Columbia College. There were at this time (1792) 55 registered physicians in New York City. In 1807 was chartered the College of Physicians and Surgeons, and Columbia then became an academic institution.

Pennsylvania.

In 1765, through the efforts of two physicians, there was opened in Philadelphia the first medical school in the colonies. It was in connection with the College of Philadelphia, sixteen years after the founding of the latter institution. Still there was no chair of chemistry till August 1, 1769. This date is interesting as exactly five years, to a day, prior to Priestley's classic discovery of oxygen, which led the way a few years later to the establishment of scientific chemistry. It was also a year after Professor Smith's first lecture in New York. Before the school was opened, the requirements provided that chemistry should be taught, but there was no apparatus, and apparently no person qualified to give instruction. Dr. Benj. Rush was the first professor. When he went abroad and brought home as a present from "the Proprietary of Pennsylvania"—Thomas Penn—a set of chemical apparatus, it was such a novelty that the fact was widely advertised. This was 132 years ago. "When the Medical School was founded the science of chemistry was little more than a knowledge of some acids, alkalies, salts and earths, of which the most important ingredients were unknown. The composition of air and water was not understood. Oxygen, hydrogen and nitrogen had not been discovered."

The Revolution broke up the medical school as early as 1779, and but little is known of Dr. Rush's success as a demonstrator. Ten years later the University of Pennsylvania sprang into existence and there were two institutions in place of one, each having its professor of chemistry. For some time but little can be recorded besides the names of those who successively held the respective positions. Rush had been transferred from furnaces and retorts to the theory and practice of medicine, and one, Dr. Caspar Wistar, took his place as professor of chemistry in the medical school of the college; Dr. James Hutchinson occupying a similar

post in the university. When in 1791 the college was merged into the university, Wispar was transferred to another department and Hutchinson retained the chemistry. On the death of the latter, three years later, the famous discoverer of oxygen, Joseph Priestley, who had just arrived in this country, was unanimously elected to the position, November 11, 1794. Priestley declined the offer, and no wonder, after a long life filled with political and religious strife which ended in his house being burned and himself driven from England. Not till the following year was the office filled, and then by the first man who seems to have made a marked impression in his specialty. This was Dr. James Woodhouse, elected July 7, 1795. He held the post till his death, fourteen years later. Of his first year it was said: "He went to work with zeal and delivered a course of lectures with great applause. As almost the whole of his time was devoted to the study of chemistry, he constantly added to the number, variety and brilliancy of his experiments. His enthusiasm was unbounded and his style sentimentally impressive." Priestley called him the equal as an experimenter of any one he had seen in England or France. Chemistry teaching at that time consisted, besides recitations, of lectures and experiments by the professor before the class. There was no mention of laboratory work for half a century. Thomson says of a still later period of the science: "Chemistry at that time did not possess a single analysis which could be considered as even approaching to accuracy." The central idea by which all experiments were explained was the "phlogiston theory" founded by Stahl in 1702. It had held its place among English chemists for a century. It was a well established canon and practically all chemists believed the doctrine. It taught that every combustible body is a compound of a very subtle substance called *phlogiston* united to a calx, or an acid; that when a substance like carbon or sulphur burns, the flame shows the escape of phlogiston, and that any residual ash is the calx or the acid, left after the expulsion of phlogiston. It was a first attempt to explain chemical phenomena scientifically, and its advent, absurd as it now seems, was a great advance over the doctrines of alchemy.

But Lavoisier, in 1778, showed that in combustion something

united with the burning material and that the something was oxygen, discovered by Priestley four years before; the fact that the substance increased in weight after burning he explained by its union with oxygen and proved that the loss in weight sustained by the air is equal to the gain in weight of the substance formed. The new chemistry gained an easy foothold in France, but not in England. Cavendish adhered to the Stahlian view, and the last chemical paper ever written by Priestley, 1803, was a defence of this theory. Woodhouse explained his brilliant experiments by phlogiston, but he was the last American professor to inculcate the doctrine.

As Philadelphia was the center of chemical study in America, Woodhouse became the teacher of teachers. Hither came Silliman, who had been appointed, in 1802, to dispense the magic art to the students of Yale, and Robert Hare—destined to surpass his master—was a student under Woodhouse. These two young men, soon to be the leaders of science in their generation, occupied the same room, performed together the experiments of their instructor, and studied phlogiston. When Woodhouse died, in 1809, the theory went out with him, and his successor, Dr. John Redman Coxe, taught according to Lavoisier. It was this Dr. Coxe who believed so fully in the efficacy of vaccination that he exposed his vaccinated infant child to smallpox, thus doing much to overcome the popular prejudice. Dr. Robert Hare, who was an unsuccessful candidate for the chair filled by Coxe, was the ablest of all the American chemists of that day, and when Coxe was transferred in 1818, he was appointed in place of the latter, having a few months previously accepted a like position in William and Mary College. He was accounted the most brilliant demonstrator of his time. After a service of 27 years he resigned at the age of 66. A report of the faculty in 1841 reads: "The chemical apparatus is, by the admission of all who have inspected it, unequaled in extent, variety and splendor. Individuals who have visited the schools of Germany, France and Great Britain agree in the statement that they have nowhere met with a laboratory so amply furnished with all that is calculated to illustrate the science of chemistry, as that of Dr. Hare." This apparatus was largely his

own invention and make. On his resignation it was given to the Smithsonian Institution, but, unfortunately, was entirely destroyed by fire in 1865.

When but twenty years old, this talented young man made one of the greatest inventions of the century, for which he was awarded the Rumford medal. It was the oxy-hydrogen blowpipe, then called the *hydrostatic blowpipe*. No temperature had ever approached that obtainable by its use, which made possible the fusion and working of platinum and other refractory metals, and opened up a new field of industry. Down to that time large "burning glasses" and huge reflecting mirrors were the chief reliance for the highest temperatures. The oxy-hydrogen flame has stood for a century as the highest heat attainable by combustion, though far outstripped in recent years by the heat of the electric furnace. Hare's invention dates from 1801. With it he experimented before Priestley, Woodhouse, Silliman and other *savants* and accounts of it were published in the press of America and Europe. Professor Silliman later said: "With Mr. Hare's blowpipe I melted lime and magnesia and a long list of the most refractory minerals, gems and others, the greater part of which had never been melted before."

In electrical invention he was no less successful. Faraday, in 1835, having exhausted his resources in trying to make a satisfactory voltaic battery, found that Dr. Hare had nearly twenty years before accomplished that end; he accordingly adopted Hare's "calorimotor," as the battery was called by its inventor.

Pharmacy was indebted to Hare for denarcotizing laudanum and for detecting minute quantities of opium in solution. In theoretical chemistry he strongly attacked Berzelius's "salt radical theory." He was "remarkable for the scale of his experiments, which were uniformly successful and impressed the mind by their grandeur." His robust frame, imposing figure and large head; his graceful language, graphic descriptions and imaginative style; the originality of his experiments and the variety and extent of the apparatus employed all combined to make Hare one of the greatest of America's chemistry teachers. He also wrote much, his contributions to the American Journal of Science being for

many years more numerous than those of any other writer. 48 volumes of that journal contain 150 articles by him, besides which he wrote an elaborate text book of chemistry and various other works.

Virginia.

In 1776, the College of William and Mary in Virginia was the wealthiest and most influential of all the American institutions of learning, but during the Revolution all its endowment, except $2,500, was lost by the depreciation of paper currency. The school suspended operations in 1781 and the buildings were burned. The first mention in the college records of a professor of chemistry is in the year 1774, and the Rt. Rev. James Madison was that professor. Chemistry appears to have been his only subject and the record is silent as to his term of service, but according to the autobiography of Thomas Jefferson, it must have been a short one. Jefferson was appointed governor of the commonwealth June 1, 1779, being elected also one of the visitors of the college. He says: "I effected during my residence in Williamsburg that year, a change in the organization of that institution, by abolishing the grammar school and the two professorships of divinity and oriental languages, and substituting a professorship of law and policy, one of anatomy, medicine and chemistry, and one of modern languages." Dr. James McClurg held the second of these posts created by Jefferson—presumably till the breaking up of the college. It thus appears that the Virginia college was the third institution to employ a teacher of chemistry; in fact it was the first one to teach the subject to under-graduates alone, not as an adjunct to a medical school—unless, indeed, the creation by Jefferson of a professorship in anatomy, medicine and chemistry constituted such a school. After an interval of over thirty years, the record shows the next teacher to have been Dr. James McLean, professor of Natural Philosophy and Chemistry, in 1812. This "college of statecraft," at which three of the four first Presidents of the United States graduated, has had some eminent teachers of chemistry, but the subsequent development of science at William and Mary does not specially pertain to the subject of this article.

Massachusetts.

The first steps leading to the establishment of a medical school in New England were taken by the Boston Medical Society, of which Dr. John Warren was the moving spirit. This was in 1780, but the plan was not matured till two years later, although Warren in his enthusiasm gave meantime some lectures on medicine at his residence. This school was to have among other things a professorship in chemistry and materia medica and Dr. Aaron Dexter was appointed to the chair. It was decided to have the institution located in Cambridge, and, besides the regular students in medicine, to allow such college seniors to attend as "had obtained consent of their parents." The school opened in 1783, and boasted one graduate each year for the first four years of its existence, though a small number more attended the lectures. Previous to 1813, there was an average of two to three graduates per year. It should be remembered that the communication between Boston and Cambridge previous to 1786, when the bridge was built, was by ferries or a long detour by land. Dexter seems to have left little record except that of "an eminently respectable character," and in 1809 Dr. John Gorham was appointed adjunct professor of chemistry and materia medica.

(*Concluded in May.*)

BIOLOGY IN AMERICAN COLLEGES—ITS METHODS AND OBJECTS.

BY FRANKLIN W. BARROWS.

(*Concluded from page 21.*)

Question 11.—Do you offer a summer course? If so, what?

Out of 92 institutions reporting, 63 answer "No."

Of the 29 institutions answering "Yes," there are 8 which either conduct their own biological stations, or make constant use of the Woods Holl laboratory. This leaves about 20 "summer schools" conducted in the colleges reporting.

Botany receives more attention than any other biological

study, 12 schools making it a specialty. Courses in general biology are offered in 5 schools, and zoölogy in 4. Each of the following subjects is made a specialty in some one of the 20 schools: Nature study, physiology, entomology, teachers' preparatory, bacteriology, industrial biology and graduate research. Several colleges report that they have had summer schools in the past but have discontinued them.

Question III.—What practical work, if any, do you carry on under the auspices of the government?

Of the 92 reports, 26 mention some scientific work for the United States or their own state. Seven are connected with Agricultural Experiment Stations, and 6 with the U. S. Fish Commission. The work of these 26 schools represents a wide range of labors, from plain "nature study" to the geographic distribution of fishes in the Pacific. Two colleges are studying grasses and other forage plants, two are making a specialty of bird migrations, while others are testing fruits and nuts with reference to their value as crops, studying the forest conditions on the great plains, the food of fishes in the great lakes, and the parasites of man and the domestic animals. One college professor is studying the annelids, and another the coelenterates of Porto Rico. A third man has assisted in working up some of the material from the "Challenger." A fourth is investigating the sponges of the Atlantic. One of our leading biologists is celebrated for his careful investigations in the interests of the oyster industry of the Atlantic coast, while another university professor conducts experiments in the propagation of Atlantic oysters on the Pacific coast.

Question IV.—Do you issue a bulletin or other biological publication from your laboratory?

Only one of the replies need be quoted in full. It is from one of our largest and wealthiest universities.

"The Zoölogical Department does not, and is opposed to the principle. The multiplication of publications that can have but a limited distribution and life is bad."

Although this policy has much to commend it, there are apparently few institutions, except the smallest, that see fit to follow it. Fifteen of the 92 reporting issue regular bulletins,

and 7 more send out "occasional" reports and monographs. In one case the output of the biological department is confined entirely to pamphlets on nature study. Eleven other laboratories report that their work is reported in the form of articles in our various journals of biology, botany, etc.

Question V.—What, in your judgment, is the chief aim and purpose of modern work in biology?

"Too big a question. There are *many* aims and purposes."

"The correlation of biological with other phenomena—the discovery and explanation of developmental laws."

"To establish genetic and phylogenetic relationships and impress the student with the value of continuity of form."

"The origin and development of the human race and the proper training and development of the individual."

"For college work the first aim is to make biology a training subject with other studies of curriculum. The work should have proper sequence to prepare for graduate work."

"(a) Philosophical—to demonstrate the unity of nature. (b) Practical—to furnish a substantial basis for a science of medicine."

"To increase that fund of human knowledge which bears most directly on the science of life. The practical importance is obvious."

"To put biology on a scientific basis, i. e., to advance beyond the old-fashioned descriptive teaching."

"Its educational value is in its training of the power of observation and of lucid exposition. Advanced study makes a valuable contribution to philosophical theory. To this latter purpose probably is directed the most important recent work."

"To accumulate, correlate and publish new facts in the life-history of organisms, in order to the ultimate construction of a philosophic system of them; an end to be hoped for only in some far distant future."

"To discover and demonstrate truth."

"The chief aim seems to be specializing on economic issues, for the purpose of making science *useful*, in its broadest sense."

"There is no *one* aim unless it be to know the truth. Problems of evolution, heredity, 'physiological morphology,' etc., are still as important as any others."

"First—To learn as much as possible about the origin and conditions of life, and about the structure, vital activities and relationships of organisms, with a view,

Second—To apply this knowledge to the amelioration of man by giving him a better understanding of his own structure and activities and greater control over those conditions (climate, etc.) and organisms which are beneficial or harmful to himself."

"On the educational side training in the methods and the logic of the observational study of nature. On the practical side preparation for the intelligent study of medicine."

"To bring the student to realize to the fullest extent the design and harmony in animate nature. To secure this result, the work must neces-

sarily be so conducted as to make it, at the same time, the best possible training of the powers of observation."

"As a purely educational or culture study it teaches the student how far safely to generalize from particular cases."

"Symmetry.—I think that morphology, physiology, ecology and taxonomy should be kept abreast."

"As in other sciences, to further the advancement of knowledge, as the only means of emancipation from error and superstition."

"In my course it is to prepare for medical studies. Attainment of technical skill, cultivation of powers of observation, encouraging scientific investigation, and increase of general knowledge are points to be attained."

"1. To teach students to think seems to me to be the great object of all scientific work, outside of the technical school. 2. As a secondary object I should say that courses in biology are necessary as preliminary to an understanding of the doctrine of evolution—its evidences, and the difficulties in the way of the theory."

"!"

"For the beginner to know life in its various manifestations and relationships. To study development from simple to complex. To acquire training in close observation and on expression. To find and stimulate the future investigator. This is college work. University work is more."

"1. From elementary, practical side—to teach practical utilization (economic, ethical, mental, aesthetic) of the forces and resources of living nature. 2. From the side of research—to extend man's actual dominion over living forces. Science is, chiefly, the knowing how best *to do.*"

"Probably to acquire and tabulate facts in the subject. Of teaching, it seems to me, to give pupil best possible realization of what life is and what it has done and is doing in the world."

"Advancement of knowledge."

"1. Learning facts by personal observation, by reading and listening to lectures. 2. Thinking about the facts of Nature and trying to comprehend them as far as possible. 3. Observation and reflection will almost inevitably lead to a feeling of sympathy and community of interest in all that lives."

"The chief aim of undergraduate collegiate work in biology at the present time is (or should be) so to instruct the pupil in the phenomena and principles of life as to fit him best to make the most of his own powers. This implies a thorough self-knowledge and a knowledge of his life as affected by his environment. This applies also, in university education, to the training for research and especially to biological training in preparation for the medical profession, with the additional element more highly emphasized in these of acquiring knowledge of life, not only for the benefit of the individual, but for the welfare of the community at large."

"It gives the student a training different from that of any other department. It teaches the student: First, to search for facts, and second, to base his conclusions on those facts and not on imagination."

"First—To develop men. Second—To give a training and a basis of fact which shall enable the few to do advanced work along this line."

"Solution of the problem of heredity."

"To gain an accurate knowledge of animal and plant life."

"The establishment of truth."

"Immediately, the furtherance of pure science. Ultimately, the amelioration of humanity by, first, broader culture; second, the specific benefits accruing to the various branches of applied science."

"Pedagogically, to develop self-reliant men in harmony with their environment. Scientifically, to study the laws underlying and conditions leading to changes in organisms."

"To develop the scientific turn of mind."

To introduce the pupil into the methods of individual research and to develop originality of thought and unbiased judgment.

To foster a love of nature and bring the pupil into a knowledge of the forms of life."

"To minister to man's two great needs—the *practical* need of better adjustment to environment etc., and a *theoretical* need of an explanation of why things are as they are."

"To find out things."

"Depends on the kind of institution where such work is pursued. In our school and for the students in the academic and normal departments it is: To acquire knowledge of *life* in nature, and to train their power of observation. For the students in our college department, I would add: To become acquainted with modern methods of investigation."

"To know 'man's place in Nature'!"

"First—To give a student some knowledge as to the origin of life and the transmutation of species. Second—To teach him to observe carefully and labor patiently for results, relying on nature itself to reveal truth, rather than on books."

"In college work, to train the general student in methods of dealing with the facts and phenomena of nature and to equip future biologists for specialization."

"Study of the nucleus and its bearing on heredity. More careful study of life in its relations to Man *should* receive more attention."

"There are two aims in this country: namely, cytology, of purely scientific importance, and economic investigation, of great practical value. Both are very strong in this country, but vegetable pathology has reached a proficiency in this country that is unexcelled. This, from my point of view, I would state is a typically American feature of our botanical work."

"The acquirement and extension of natural knowledge, the cultivation of human faculty, and the better conduct of life, based upon and guided by a more intimate knowledge of and a closer touch with Nature."

"Its aim should be to teach function rather than structure, both to students of medicine and as a part of a liberal education. Perhaps I should say—structure as a preliminary to function, using the latter term in the broadest possible sense."

"To give man an understanding of the living world about him, of his relations to it, and of himself."

"It ought to be, to teach man what *life* is, his relation to *life* and his relation to his fellowman."

"To render the student ordinarily intelligent in regard to the *general principles* of biology, as a help in using common sense in the affairs of life."

"Aside from mental training and advancement, the aim is to improve sanitation, medicine, surgery, agriculture, horticulture, etc.—not simply to support some pet theory."

"I do not understand this question."

"(a) Training in critical observation and interpretation. (b) The information and culture demanded by modern life."

"To acquire knowledge of living organisms and underlying laws or principles, with the applications to human interests, in medicine and various industries, that may follow such knowledge."

"Don't know just what the question means—investigation or instruction? And don't know how to answer."

"In general, to awaken an intelligent interest in Nature. In particular, to prepare for a professional education."

"1. To awaken and direct interest in Nature. 2. To teach the laws of sound living. 3. To train the mind to patience, the eye and hand to accuracy in noting and expressing details."

"As a rational basis for philosophy."

"To find out laws which control organic life."

"*Research, to solve mooted questions.* To cultivate power of original observation and thought in students. To broaden the intellectual horizon, and to overcome narrow orthodox views. Each worker's environment determines in a measure the trend of his personal work."

"1. An insight into fundamental life processes, and their correlation throughout entire living world, including man. 2. An insight into phylogeny, as the key to a true history of life. 3. A scientific foundation for medical and sociological work."

"In the college, primarily, to train the student in accurate and truthful habits of observation and thought. Biology leaves the impress of *scientific method* upon the average mind more efficiently than any other science. Secondarily, to acquaint the student, thoroughly and sympathetically, with nature in its common aspects, and with his own body. In the university certain professional or technical aspects may legitimately become the chief aim and purpose,—not so in the college."

"If by work you mean educational work: to give people sources of interest in after life as well as present, and to help them to appreciate the scientific method, and to believe in the results—that is, to be more rational."

"To throw light on the Evolutionary Hypothesis."

"Training in accuracy of work. Clearness in reasoning."

"To find an answer to every reasonable question concerning living things and make the knowledge of living things as useful as possible to man."

"This is a very large question and I can answer it here only in a broad general way. To get at the nature of *Living* Beings, I should say."

"To teach students to *do,* not to learn what others have done and said."

"Beg to be excused."

"Training of powers of observation and acquisition of knowledge of the laws of organic development."

"For a university, *investigation;* from the teacher's standpoint, *discipline.*"

"Discovery of causes of formative processes of organic development."

"To gain some knowledge of the structure, physiology and taxonomy of plants and animals, so that we may have some idea as to their origin, individually and phylogenetically, and their relationship to one another and to their environment."...."I am not certain that my answer is the best, but it comes pretty nearly expressing what has been in my mind for a long time."

"Seeking to know the laws that govern life, and contributing to a 'perfect culture' as defined by Huxley."

"I consider modern biology as the natural avenue to medicine. Theoretically it is a factor in education and practically it leads to a knowledge of the natural resources of the country."

Here are seventy-four of the eighty replies vouchsafed by ninety-two professors. It is not to be wondered at that a dozen of these biologists refused to commit themselves on such an important question, or that a half-dozen couldn't understand the point,—or something of the sort. Who that knows much of our professors of science would expect more than four-fifths of them to hold very clear ideas as to what they are driving at? How many readers of SCHOOL SCIENCE, by the way, can define distinctly their own aims or the aims of the leaders in their special lines of work?

Even those who have sent in straightforward answers to this question have in many cases protested against the inquisition, and thus, we hope, felt the necessity of particular caution in committing themselves. For this reason the answers are worthy of careful consideration in themselves, and need only a brief analysis.

One-third of these opinions consider the science of life a sufficient end in and of itself. More than half of them regard the development of the observational powers and the acquisition of a scientific method as the chief aim. One-quarter of the opinions rank evolution and heredity as the leading biologic questions, while as many more would place economic biology at the front. One-sixth of these professors teach biology mainly as a preparation for the study of medicine,—a service that does not meet with the recognition that it deserves in most of our medical colleges. One-sixth aim to discover the truth for its own sake, or as a basis for a sound system of philosophy. About one-tenth believe that

the highest purpose of a course in biology should be to implant in man a real interest in nature.

Probably nearly all of these teachers would agree with Professor Sedgwick, of the Massachusetts Institute of Technology, that our study of biology is tending toward a "better conduct of life, based upon and guided by a more intimate knowledge of and a closer touch with Nature."

SHALL THE PREPARATION OF A HERBARIUM AND THE IDENTIFICATION OF SPECIES FORM A PART OF THE REQUIRED WORK IN BOTANY IN OUR SECONDARY SCHOOLS?*

BY GILBERT H. TRAFTON.
Normal School, Randolph Center, Vt.

It is something of a temptation to assign myself the pleasant task of culling out from the things that might be said on this subject only those that would meet with the approval of you all. But however pleasant such a task may be in thought, I find two serious objections to such a procedure. In the first place, with the present unsettled conditions of methods in teaching botany, it would be an extremely difficult, if not almost impossible undertaking to find those things upon which all would agree, without reducing my remarks to such small compass that they would not justify my appearance here. But secondly and for my purpose more important, I consider that the benefit to be derived from our discussion will be greater if we attack those difficult problems that we encounter in our teaching and see if we can find any suggestions concerning their solution. Accordingly, I propose to discuss one of the much debated questions of botany teaching: Shall the preparation of a herbarium and the identification of species form a part of the required work in botany in our secondary schools? And as I propose to discuss this question in its bearing

*Read before the Vermont Botanical Club in Burlington, Jan. 25, 1902.

on our local, Vermont conditions, our problem will still further resolve itself into the consideration of courses of a half year or less, as there are very few schools in our state that give two terms to botany, as far as I know, none that give a whole year.

From statistics taken by Professor Jones a few years ago, I infer that I shall have many critics defending my own answer to the question, which is expressed emphatically in the negative. I wish, first, to state some of the objections that may be raised against the methods which we have under discussion, then to indicate briefly what the new botany has to offer in place of the old, and finally to show how some of the authorities of our country stand on this question.

Against the preparation of a herbarium as required work, I see the strongest objections and I could find no justification for myself should I require all my students to be stretched on this Procrustean bed, although it might be left as optional work for the interested few.

The kind of work necessary to get the flower finally prepared for keeping is largely not botanical. That part of it which brings the student into the field to see nature first hand is most admirable, but from there on, the laying out of the flower that it may be beautiful in death, the applying of dryers, the adding of weights, the frequent changing of dryers, the transferring to the mounting sheet and its attachment there, together with the other details necessitated do not teach the student botany. And the value that such a collection might possess had it been obtained with some definite plan in mind to illustrate the principles of morphology and ecology is entirely lost by allowing the student to collect at random any plants, so long as the required number has been secured.

Against the use of keys for the identification of species, I would offer first the objection that such work is too difficult for the average student in our botanical courses, which are usually placed in the first years of the high-school curriculum. The determination of species, as the members of this Botanical Club well understand, is a work for the specialist, not for the beginner. In thus introducing our boys and girls to the species, at the very outset we are bringing them into one of the most puzzling and disputed

realms of biology. What is a species? I should almost venture to say that hardly any two of our definitions would agree. Our biologists are realizing that it is a difficult thing to draw a hard and fast line between allied species. The more individuals and varieties are studied, the more bad species are found, till some are almost ready to assert that if we knew the life around us thoroughly, a majority of our species would prove bad. Thus whether we shall call two allied forms species or varieties depends upon our ignorance of or acquaintance with the intermediate forms. And so this question of species has come to form one of the disputed fields of the Weismannians and the Neo-Lamarckians.

Another objection to the use of keys is that the student acquires a very one-sided and partial idea of plants. The flower forms the basis upon which the determination of species depends, and as the student continually studies flowers and flowers alone or chiefly, it is no wonder that in many minds the word flower is almost synonomous with plant, and naming plants by means of the flower, synonomous with botany. To be sure, in the study of flowers there is opportunity to study that beautiful interdependence of insects and flowering plants, but even this is usually overlooked in the mad scramble to secure the fiftieth plant.

And lastly against the specialized and detailed study of the Angiosperms by either or both of these methods which are under discussion, I would object that the plan is unsymmetrical and out of proportion. From the four great subkingdoms and the eighteen to twenty classes one single class is selected and a large part of the time is spent on the flowers of the plants found here to the exclusion, not only of all the rest of the plant kingdom, but of the really essential features of that very class which is being studied. If this plan is defended on the ground that it is better to study the common plants and those which do not require the use of compound microscopes, one would naturally ask why, then, other plants which meet these conditions have not been included, such as the conifers, ferns, mosses, horsetails, lycopods and mushrooms.

Let no one misunderstand me as saying that this work which I have been condemning is of no value to the student. That is far from my purpose. My contention is that the time thus spent can

be occupied otherwise with far more profit. And right here is my strongest point. All I have said would be valueless were there nothing to offer in the stead of that which I would displace. My chief argument is that the new botany has vastly more to offer than the old. Accordingly it will be in keeping with my subject and purpose to outline briefly what the new botany has to offer to substantiate this claim.

At the outset I wish to say that no expensive apparatus is demanded. I understand the conditions in many of our schools well enough to know that if the new botany required a large outlay, it would be unpractical for me to discuss the matter here. But such is not the case. Expensive apparatus is often convenient but not essential. The financial question, therefore, need not enter into our discussion.

The contrast between the old and the new may be briefly expressed by saying that the old is the study of the dead, the new, the study of the living. We find here the same spirit that is permeating so much of the modern teaching of biology and geography. It is hardly necessary for me to say that boys and girls are much more interested in life and the living than in the dead and the dying. And not merely is it a question of transient interest, but that knowledge of plants which will prove of lasting interest and benefit to the boy as he grows to manhood is also connected with the life problems of the plant kingdom. To give but two instances. The dismantling of our beautiful country by the removal of the forest is a menace to coming generations. How better can this danger be averted than by teaching our boys and girls about the life work and problems of the trees and the dependence of mankind upon their proper care? And again, many of our boys will engage in agricultural pursuits. Proper instruction in the life processes of plants may foster an interest in and prove the basis of more careful study of those problems, the understanding of which will enable the farmer to be more successful with his crops, forests and orchards.

The various phases emphasized in the new botany may be placed under three heads, physiology, ecology and morphology. And for convenience we may divide the last head into three sub-

heads, general morphology, or the study of types; gross morphology, or the study of the plant organs; and special morphology, or the detailed study of the Angiosperms. The place to be assigned to this last topic is the question which we have under discussion. Whether general morphology shall form a part of the half year course or not, is one of the questions on which authorities differ, although they lean toward the negative. And as our Vermont schools can not generally afford the apparatus necessary to make such a course profitable, we will eliminate this topic from our consideration. Thus we have left for our discussion physiology, ecology and gross morphology. Because it is convenient and customary to speak of these topics separately, it must not be inferred that they should be treated so in actual study. The physiologist finds it convenient to describe separately the heart, arteries, veins and capillaries; but in actual dissection they are studied as parts of one great system. Likewise the various topics of botany must be closely related in study as they actually are in nature. A slight knowledge of gross morphology may form the center around which may be woven and interwoven the facts of physiology and ecology.

I know of no better way than to trace the history of an individual seed plant through all its stages of growth, beginning with the study of the seed, followed by that of the root, stem, leaf, flower and fruit, thus bringing us back again to the seed and completing the cycle. In connection with the study of the morphology of the plant organs should be taken up the work done by them, that is, physiology; and their problems, that is, ecology. In short, create and foster in the student an intimate, personal and living interest in the great plant world around him.

While studying seeds, the wonderful adaptations for their dispersal should receive attention, by field work when the season permits. Experiments may be performed to ascertain the conditions necessary for germination. With germinating seeds, also, may be shown the need of oxygen for the respiration of the plant, and thus the truth may be emphasized that plants, as well as animals, require oxygen. The path of the sap in the root and stem may be shown by using colored liquids. Osmotic pressure may be demonstrated by means of an egg. In connection with the study of the

leaf, experiments should be performed to show photosynthesis and transpiration. While studying the flower, the relations of insects and plants and the remarkable adaptations for cross-pollination should receive attention.

That most remarkable of all the plant's powers, its irritability, as shown in hydrotropism, geotropism and heliotropism, should be carefully studied; and more especially should be emphasized the light relations of the plant and in particular of the leaves. The mechanism of animals for response to light is extremely crude compared with the wonderful sensitiveness of the plant which brings about those most marvelous and delicate adjustments that best adapt it to its environment. Field excursions should be taken to study these adjustments in the common trees. Before the leaves appear, the branches should be closely examined and the record of their struggle for sunlight deciphered. A little later, the leaves should also be besieged to reveal their story. For these studies, I have found the maple most excellent.

(*Concluded in May.*)

A MOUNTING FOR AN OSCILLATING MIRROR.

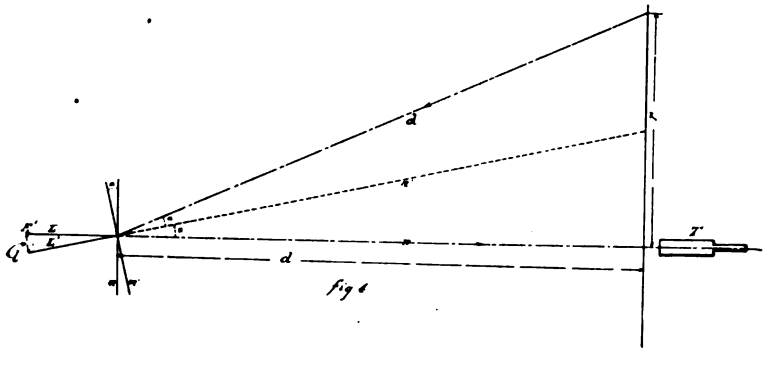
BY E. C. WOODRUFF.

Instructor in Physics, La Grange (Ill.) High School.

Many experiments in elementary physics as described in the laboratory manuals involve errors inherent in the methods given greater than the observational errors of the veriest tyro. Obviously such methods are not desirable. The most sensitive and accurate apparatus compatible with simplicity and ease in working is just as desirable for those experiments which are intended mainly to vivify laws, as for those whose results have in themselves an intrinsic value. While the high-school laboratory should not become merely a place for training in manipulation, still it seems highly desirable that most experiments not otherwise too complex should include a certain amount of training in method and

mechanism just a little above the previous experience of the pupil.

There is a certain method of observation rather neglected in high-school work in spite of its simplicity and general applicability. The mirror and scale method, with or without a telescope, is the method to which attention is called. Perhaps a general description of the theory and practice of the method will not be out of place before taking up the special reason for the writing of this article. In general, then, when one wishes to measure a small rotational motion, or its equivalent, one attaches a mirror to the rotating body, sets up at a convenient distance from the mirror a scale perpendicular to the axis of rotation, and then observes through a suitably placed telescope the motion of the image of the scale in the mirror. In Fig. 4, T is the telescope, r the scale,



and m and m' the mirror in two positions corresponding to the positions of the body, L and L'. Let d be the distance from mirror to scale, and n and n' the normals to the mirror in its two positions. Suppose that initially, in the position m the normal n passes through the zero line of the scale and also along the optical axis of the telescope. Then the observer will see the zero line coincide with the cross-hair of the telescope. Now if the body, mirror and normal rotate through the angle α to the positions L, M' and N' the mirror will be in the position to reflect light from the scale division on the line P along the axis of the telescope. Let r be this scale-reading. Then the large apparent motion r is what

is directly observed instead of the relatively small displacement l of the point F' in the rotating body, and the motion of F' is magnified in the ratio $\frac{r}{l}$ which ratio may be of any convenient value controlled by varying d. Now the observer is in a position to do any one of three things:

(1) A small motion of the body may be easily detected. This is the use of the method in the "zero methods" in galvanometer work.

(2) One may compare successive motions of the body by calculating from $\frac{r}{d} = \tan 2\alpha$ the ratios of the various α's, or if the angles α are all small the ratios of the successive r's will give the relative motions with but little error.

(3) One may calculate the actual displacement l from a knowledge of L, d, and r. This may be done in two ways:

(a) $\frac{r}{l} = \tan 2\alpha$;—(i), and $\frac{l}{L} = \tan \alpha$ (nearly);—(ii).

Solve (i) for α and then solve (ii) for l.

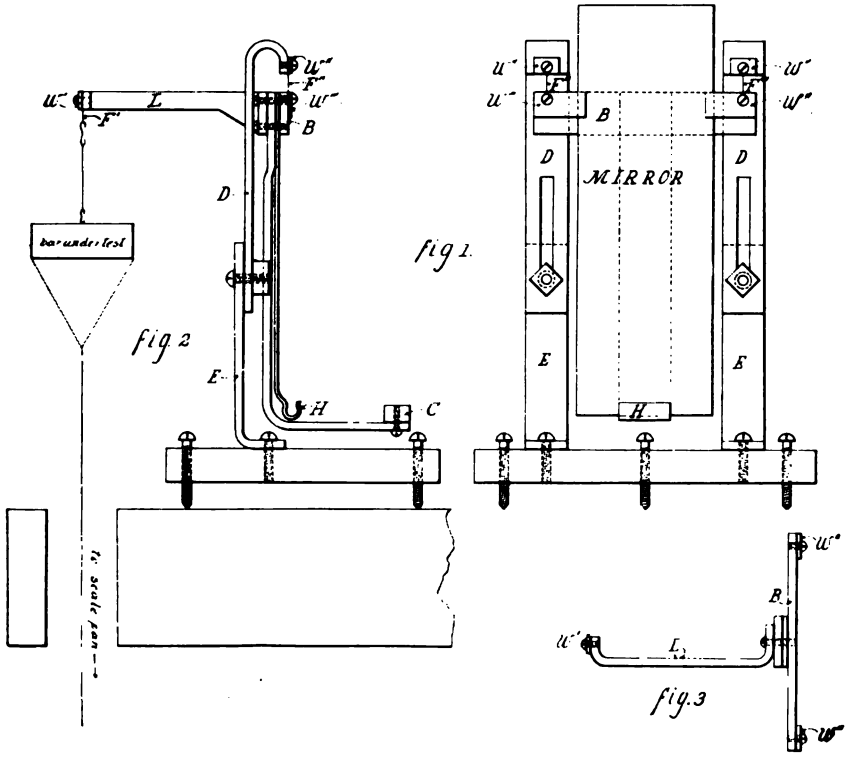
(b) If α is small,

$$\frac{l}{\frac{1}{2}r} = \frac{L}{d} \text{ or } l = r\frac{L}{2d} \text{ (very nearly).}$$

Method (b) is perhaps the best for student use since it is so easily grasped (as an approximation) from similarity of triangles. The error involved is very small, about ¼ per cent when α is in the neighborhood of 3°, as will be shown in detail later.

All three ways of using the method are used successfully by the writer's pupils, each in at least one experiment. There are certain standard experiments, notably those in elasticity of flexure, extension and torsion, which seem as described in recently published manuals to have the defects mentioned at the beginning of this article. The plan for a mounting for an oscillating mirror submitted in the accompanying drawing is designed to show how an oscillating mirror may be used in experiments of the above mentioned types, and especially in the measurement of elasticity of flexure. The special objects of the design were to secure ease in assembling apparatus, steadiness and uniformity in action, ease

in attaching the device to rods, tubes, and bars of widely differing cross sections, and the adaptability of the one design to many experiments. Likewise it was desired to have something that could be constructed from common stock, with simple tools, and yet that would admit of as exact and substantial a construction as one could wish. Fig. 1 shows a front elevation without the counter-



poise. Fig. 2 shows a side elevation with the mirror omitted, but with an indication of the method of attachment to a bar under test. Fig. 3 shows a top plan of the lever arm L and cross bar B. The dimensions of the various parts can be deduced from the size of the mirror, one by three inches. All the metal work is of brass. Most of the details of construction will be sufficiently evi-

dent from the drawing. The letters indicate the same parts in the four figures. C is a counterpoise of such a value as to offset the weight of the lever L, and to furnish a slight restoring force.

A special feature is the use of the three silk threads F', F'', and F''', pinched under the thin washers w', w'', and w'''. The motion is as perfect as one could wish, and occurs where the threads are flexed just as they enter the cracks between B and w''', and L and w'.

The actual strain of the bar can be readily calculated from the length of L and the measured distance from the mirror to the scale. The attaching of whatever object whose motion under stress is to be observed is accomplished simply by the use of small wire hooks and loops of thread.

The details of an actual experiment as performed by students are cited below; taken, with a few slight changes, direct from their note books:

January 22, 1902.

ELASTICITY OF FLEXURE OF A BRASS ROD.

Diameter of rod = 0.64 cm.
Mirror to scale.....178 cm. = d.
Lever arm of mirror....4.3 cm. = L.

	Length = 100 cm.			Length = 50 cm.		
Load grms.	Reading cm.	Difference	per 20 grms.	Reading cm	Difference	per 20 grms.
0	13.05	....	....	11.75	....	....
20	16.65	3 60	3.60	12.25	0.50	0.50
0	13.05	....	....	11.75	....	....
40	20.35	7.30	3.65	12.7+	0.95	0.47+
0	13.0+	....	....	11.75	....	....
60	24.05	11.05	3.68	13.2+	1.45	0.48
0	13.05	....	....	11.75	....	....
80	28.05	15.00	3.75	13.65	1.90	0.47+
0	13.05	....	....	11.75	....	....
100	31.4±	18.35	3.67	14.1	2.35	0.47
0	13.05	....	....	11.75	....	...
120	35.15	22.10	3.68	14.55	2 80	0.46+
0	13.05	....	....	11 75	....	....
140	38.9—	25.85	3.69	15.05	3.30	0.47
0	13.05	....	....	11.75	....	....
160	43.05	30.00	3.75	15.55	3 80	0.47+
0	13.0—	....	....	11.75	....	....

180	46.85	33.85	3.76	16 0—	4.25	0.47
0	13.0±	....	....	11.75	....	....
200	50.5	37.5	3.75	16.45	4.70	0.47

NOTE: To stop vibration the tab'e was supported on four rubber stoppers, and a second pan submerged in water was attached below the scale pan proper.

CALCULATIONS:

(*a*) *With a stress of 200 grms.;*

Scale reading:

For 100 cm. length = 37.5

" 50 " " = 4.7

But $\frac{37.5}{4.7} = 7.97+$, and $\left(\frac{100}{50}\right)^3 = 8$

∴ The strain varies as the cube of the length.

(*b*) *To calculate the actual deflection:*

For 100 cm. length and 200 grms. stress;

Actual deflection $= l = r\,\frac{L}{2d} = 37.5 \times \frac{4.3}{2 \times 178} = \underline{0.4529 \text{ cm.}}$

(*c*) *To calculate Young's Modulus:*

For a rod supported at both ends,

$$\text{Modulus} = \frac{4}{3}\,\frac{\text{Weight} \times (\text{length})^3}{\pi \times (\text{diameter})^4 \times \text{deflection}}$$

$$= \frac{4 \times 200 \times (100)^3 \times 178 \times 2}{3 \times \pi \times (0.64)^4 \times 4.3 \times 37.5}$$

$$= 1.117 \times 10^9 \text{ grams.}$$

$$= 1.094 \times 10^{12} \text{ dynes.}$$

Curves, of course, were constructed showing the stresses as abscissas and the strains as ordinates, which curves demonstrated Hooke's law admirably.

It will be noticed that the student used the approximate formula for calculating the actual strain. If the strain is calculated by trigonometry, one gets 0.4492 cm. The error, then, is about 0.03 millimeter or less than 1 per cent. However, the angle was large, about 6°. Taking the strain for a stress of 100 grams and making the same calculation one obtains: By approximate formula $l = 0.2216$ cm.; by trigonometric formula $l = 0.2211$, or an error of about 0.005 mm. or less than ¼ per cent. The angle was nearly 3°.

Ordinarily the pupil would not calculate Young's modulus, nor solve for l by trigonometry, though either step is simple enough for the stronger purpils. Even if one cannot deduce the formula

for the modulus by flexure, still it is of value to calculate the modulus, the formula being assumed, so as to compare with the modulus by extension. None need have difficulty with the derivation of the formula for extension.

A partial list of experiments to which this device is applicable would read as follows:

(1) Elasticity of flexure.
(2) Elasticity of extension.
(3) Elasticity of torsion.
(4) Coëfficient of expansion by heat of solids, liquids and gases.
(5) Instead of a cathetometer to measure small distances.
(6) As a sensitive balance by hanging a scale pan from *L*. The observer can place the telescope alongside the mirror by using an auxiliary, stationary mirror placed near the scale. Either the method of constant deflection or Hooke's law can be used, just as with the Jolly balance.
(7) Instead of using a pointer on any balance, *L* might be attached to the beam and deflections observed in the mirror.
(8) As a magnetometer, especially for exploring a magnet from end to end.
(9) As a suction ammeter.
(10) As a suction voltmeter.
(11) To demonstrate the laws of moving mirrors.
(12) To measure the diameters of wires or the thicknesses of metal plates.
(13) To measure the angles subtended by inaccessible objects, either terrestrial or celestial, the telescope remaining fixed.

In numbers 1, 2, 3, 4, 6, 7, 8, 9 and 10 the mirror would be fastened to the moving object. In numbers 4, 5, 12 and 13 a screw motion mechanism would be fastened to *L*, either with or without a micrometer head. To be sure, all of these possibilities are not adapted to high-school work. Numbers 1, 2, 6, 8, 9 and 11, however, are especially desirable. Pupils seem to have no difficulty in assembling or using the apparatus after it has been once set up, explained, and taken down. I wish to emphasize the teaching value of the "taking down."

If any teachers contemplate using such an apparatus for such work, I should be glad to hear from them with regard to any difficulties or any successes they may have.

ANOTHER HELIOTROPE.

BY E. C. CASE.

A great many heliotropes have been devised for experiments in physiography to determine the height of the sun, but I have one that seems to me to present certain simple and advantageous features. It consists of two supports, *a* and *b*, (Fig. 1), fixed rigidly at a right angle. In the upper face of *b* is fastened a narrow strip of mirror so that its upper face is exactly perpendicular to the upright *a*. In making the apparatus, I plumbed the upright, and then cut a small hole in the base and filled it with

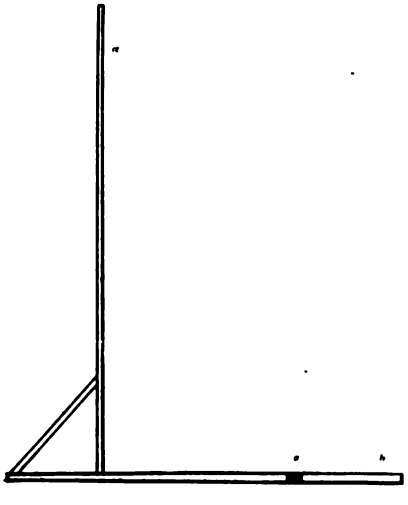


Fig. 1.

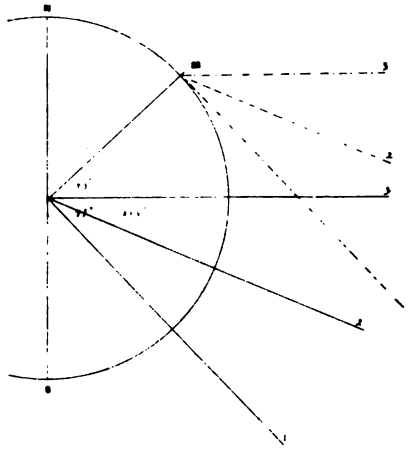


Fig. 2.

plaster of Paris, in which I laid the strip of mirror and leveled it with a small pocket level as the plaster set. A protractor was then set up with its middle point on the center of the strip of mirror, and a thread drawn to the upright, marking every degree from 15° to 75°. The greatest length of the strip of mirror is across the base, of course.

The method of use is simply to set the heliotrope in the sun

and read the middle point of the reflection cast on the scale. The real noon can, of course, be determined by noting the highest point of ascent, though this is not very exact. The azimuth of the sun can be determined, the noon line or true north once determined, by turning the apparatus toward the sun, one end of the base being fixed on the noon line, until the middle of the reflection lies upon a line ruled down the middle of the upright; then the angle of the apparatus to the true north line is determined, and we have the sun position in alt- and azimuth.

My method of explaining altitude experiments to the class is as illustrated in Figure 2. It may be old, but I haven't seen it anywhere. The sun's rays are parallel to themselves and fill a space certainly much greater than the earth. Then, if the sun is tangent at Milwaukee (Lat. 43° N.), they will be vertical over 47° S. latitude. This is shown by the whole line and dotted line 1. If the sun is vertical over the tropic of Capricorn, 23½° S., the ray, parallel to this vertical ray, which strikes Milwaukee will be 23½° from the tangent to Milwaukee, just as the vertical ray is 23½° from a point 90° from Milwaukee, and so the sun at Milwaukee will appear 23½° above the horizon. (Whole and dotted lines 2.) When the sun is vertical over the equator the parallel ray at Milwaukee will cause the sun to appear 47° above the horizon, for just as the equator is 47° from a line 90° from Milwaukee, so the ray striking Milwaukee will be 47° from a ray tangent to Milwaukee. So, for the summer solstice the sun will appear 70½° above the horizon.

Now, if a mirror were placed parallel to the horizon at Milwaukee, the law of reflection of light would cause the light from the sun to fall on a convenient scale and register the sun's height directly.

The advantage of this device is its exceeding simplicity and ease of setting up. The height of the sun can be read directly, and its change of position is very noticeable. My very hastily constructed model reads readily within a quarter of a degree of my transit.

MAGNETIC PHANTOMS.

BY JESSE H. GARNER,

Professor of Chemistry and Physics, Findlay (Ohio) College.

In the study of magnetism, we often illustrate the field of force, lines of force, and the law of attraction and repulsion of poles by means of iron filings on a sheet of paper or glass, under which is placed the source of magnetism. It is often advantageous to preserve these magnetic phantoms, and I shall give a few simple processes (not original with me) that have proved successful in our laboratory.

These processes may be grouped under two heads, chemical and adhesive.

Of the chemical processes, two are given below:

1. *Tannic acid.* A solution of tannic acid may be prepared by boiling 10 grams of powdered nutgalls in 60 cc. of water for several hours, from time to time replacing the water lost by evaporation.

If now a magnet be placed in position below a plate of glass and iron filings be sprinkled upon the glass, they will arrange themselves into a well-defined figure upon tapping the plate with a pencil. The filings should not be too fine and they may be sprinkled from an ordinary salt shaker.

A piece of writing paper is now coated on one side with the tannic acid solution, using a camel's hair brush or a tuft of cotton to spread it. Immediately place it, wet side downward, on the filings, place another sheet of paper above it and press down gently. Raise the paper *carefully* so as not to disturb the filings which stick to it, and lay aside to dry. When completely dry, brush off the filings and there will remain a mark wherever a particle of iron came in contact with the tannic acid.

2. ***Photography.*** This method is the best we have tried, though where the item of expense must be considered, it is at a disadvantage. Furthermore, it requires a dark room and some knowledge of photographic processes.

Any of the ordinary dry plates may be used, though slow plates

are perhaps the best. In the dark room, using red light, place the magnet in position under a dry plate having its film side up. Sprinkle on the filings and tap as described above, then light a match and hold it about one foot above the plate for a short time. This time depends on the speed of the plate, but usually sufficient exposure is obtained before the match is completely burned. Develop and print as with an ordinary exposure in a camera. This gives a clear-cut phantom and has the advantage of supplying as many copies as one cares to print from the negative.

Of the adhesive processes, three are given below:

1. *Shellac.* Bleached shellac is dissolved in enough alcohol to make a thin varnish. The phantom is produced on a piece of paper or thin cardboard by placing a magnet in position below the paper and sprinkling filings on above as in previous cases. By means of a glass tube used as a pipette the shellac is made to flow over the paper and among the filings, care being taken not to disarrange the particles of iron. This shellac soon hardens and thus retains the filings in their places.

Another method of using shellac varnish is as follows: A piece of paper is coated with the shellac and allowed to harden sufficiently to prevent the filings sticking to it. A phantom is then made on this piece of paper and when the particles are all in place, steam is made to pass over the surface of the shellac. The heat softens the varnish enough to take hold of the filings and on again hardening they are held in place.

2. *Paraffin.* Paraffin wax is heated until liquid, and one side of a piece of paper or thin cardboard is coated with it. When cold, produce a phantom upon the paraffined surface, then heat by holding above it some heated object, as a metal plate or pan of hot sand or water. As soon as the wax softens, the filings sink into it and become fixed in position when the wax again cools.

3. *Flour paste.* The ordinary flour paste of medium thickness is used. The phantom is made on a plate of glass, and the sheet of paper, previously coated on one side with the paste, is carefully placed upon it. Remove and dry quickly to prevent the iron rusting.

This last process is more satisfactory than the other adhesive

processes. For individual experiments for each member of a class, I would advise using either it, or the tannic acid process, since the average pupil will succeed better with these than with the others.

Permanent magnets, either bar or horse shoe; like or unlike poles near each other; consequent poles; induced magnetism in soft iron, with inducing magnet near; electro-magnets with or without a core, etc., make good phantoms, if magnetism is powerful enough to make a strong field.

A DEMONSTRATION OF VAPOR TENSION AT ORDINARY TEMPERATURE.

BY C. E. LINEBARGER.

The need for a correction to the pressure of a gas collected over water due to its being permeated with water vapor is not very clear to the student, unless the fact that the vapor of water exerts a pressure at ordinary temperatures is brought home to him by a special demonstration. A usual method of demonstrating the phenomena of vapor tension in general consists in introducing a little of the liquid into the vacuum of a Torricellian tube. The lowering of the mercury is so slight, however, that with water it requires quite close observation to perceive it, unless special precautions have been taken to insure the dryness of the tube and mercury. Also the manipulation with mercury is not very convenient. Still, for volatile liquids such as ether or carbon bisulphide, the method is very well adapted.

The apparatus to be described, however, even with water gives indications of a change of pressure that are plainly apparent at quite a distance and has the advantage of not requiring the use of mercury. It consists (Fig. 1) of a small wide-mouthed bottle fitted with a good cork pierced with three holes. Through one hole passes a manometric tube filled with kerosene, through another an L-tube and through the third a straight tube with a bulb of thin glass blown at one end. This bulb tube may need a little more detailed description. The bulb may be of any convenient size, and

need not be spherical. Indeed, the more irregular its shape, the better, for then it may be crushed the more easily. The open end of the bulb tube, which should be drawn out to a small diameter, is placed in water and the air in the bulb and tube heated by play-

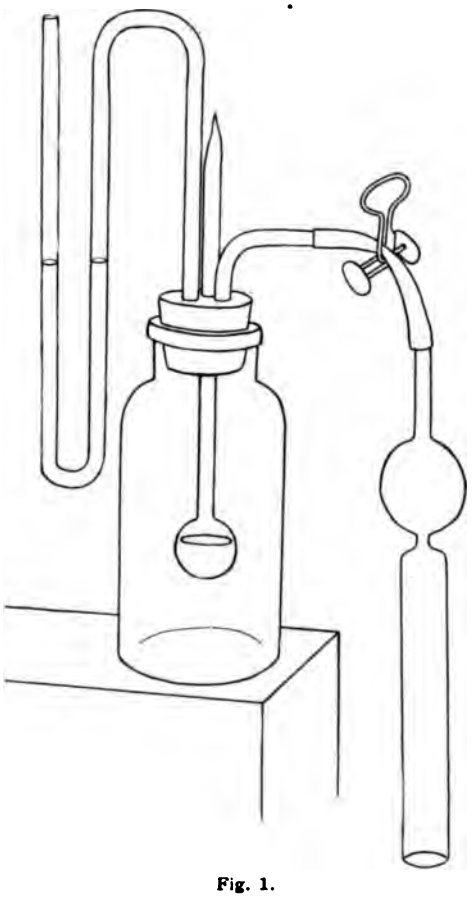


Fig. 1.

ing a flame over it. During cooling, water enters to take the place of the air driven out by the heating. The drawn-out end is then melted together in a flame. The stem of the bulb tube should be

rubbed with a little vaseline so that it moves easily through the cork.

Care should be taken that the bottle and tubes are as dry as possible before putting the apparatus together. It is advisable to set up the apparatus and let it stand for some time with a chloride of calcium tube attached to the L-tube.

When the experiment is to be performed, the bulb is pushed down nearly to the bottom of the bottle and the bit of rubber tubing over the L-tube is closed with a pinch cock so that the kerosene stands at the same level in both branches of the U-tube. The bulb is crushed by pushing it down suddenly against the bottom of the bottle, and then raised so that as much of it projects above the cork as at first. As the water vaporizes, the kerosene moves in the manometer so that in a few seconds or so a difference of level amounting to more than 10 cms. is observable.

Of course, other liquids besides water may be taken. Ether has such a high vapor tension at ordinary temperatures that mercury instead of kerosene should be used in the manometer.

ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY.

BY GEORGE W. MYERS.

(*Continued from page 40.*)

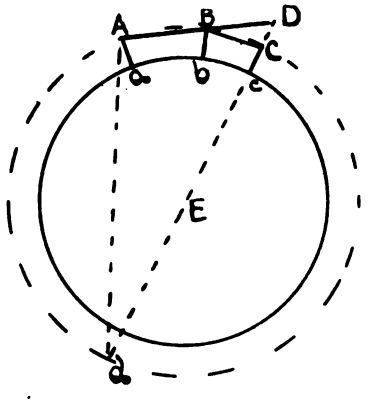
EXPERIMENT XXXI.

Find the length of earth's radius by Wallace's method.

Let *A, B, C* of the figure be the tops of three posts of same height above water-level set up along the shore of Lake Michigan or by the side of a straight canal. Sighting from *A* over *B* the line of sight will cut the vertical post at *C* at a point *D* above *C*. The points *A, B,* and *C* will be on a circumference concentric with the circumference *a, b, c* of the earth's surface. Let *C D,*

$B\,D$, and $A\,D$ be measured. Suppose the vertical $D\,c$ meets the circumference A, B, C at d.

Then by elementary geometry, since $B\,A\,d = B\,C\,D$, and



Wallace's Method.

Fig. 28.

$B\,D\,C$ is common to the triangles $B\,C\,D$ and $D\,A.\,d$, these two triangles are similar, and

$$\frac{d\,D}{A\,D} = \frac{B\,D}{C\,D} \text{ or, } d\,D = \frac{B\,D}{C\,D} \times A\,D.$$

But $d\,D = 2\,r$ (nearly); r denoting the radius of the earth. Hence

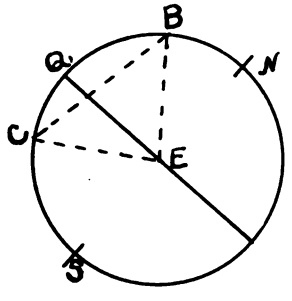
$$r = \tfrac{1}{2}\frac{B\,D}{C\,D.} \times A\,D.$$

Experiment XXXII.

To find the radius of the earth.

After the latitude and longtitude of points on the earth's surface are found, it is possible to determine the radius of the earth in miles. The geographical coördinates of the Observatory of Berlin are given in the Jahrbuch as Longitude + o h. o m. o. s. and Latitude + 52° 30″ .2, and for Cape Town, South Africa, Longi-

tude —0 h. 20.3 m. and Latitude — 33° 56′. Supposing the earth to be a sphere, and that the two stations, as *B* and *C*, lie on the same meridian (which is roughly true for Berlin and Cape Town, and the discrepancy can be allowed for), compute the radius of



Earth.

Fig. 29.

the earth, *B E*, and the chord extending from Berlin, *B*, to Cape Town Observatory, *C*, assuming the measured length of the great circle arc, *C Q B*, to be 6,495.6 miles.

Using the 18″ terrestrial globe and scale of both miles and degrees, determine the radius of the earth from measures of arcs of great circles between various places.

Hipparchus found that on March 31st at noon the sun shone vertically into a deep well at the city of Syene, 500 miles south of Alexandria, while at the latter place the gnomon showed that at noon of the same day the sun was south of the zenith by $\frac{1}{50}$ of a circle ($=7°.2$). What would these data indicate the circumference and radius of the earth to be?

[Note: The arc Berlin-Cape Town is not the one actually used but it will suffice to illustrate the method as well as the one actually used, and these stations are needed in the next experiment.]

Experiment XXXIII.

To find the distance to the moon.

The stations used above, Berlin and Cape Town, will exemplify the present problem. The observer at Berlin, *B*, measures

the altitude, *N1 B M, or zenith distance, Z1 B M,* of the moon, by means of the most accurate instruments available, constructed on the principles crudely represented in our hand quadrant, or Tycho's quadrant. So also does the observer at the Cape Ob-

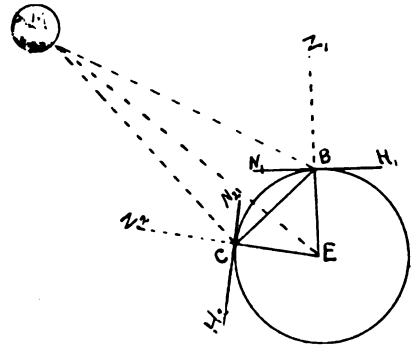


Fig. 30.

servatory, *C,* measure the zenith distance, *Z2 C M,* or the altitude, *N2 C M,* at the same time as does the observer at *B.* The time is set by previous agreement. The former experiment gave us *B E* (= *E C*) and *B C.* The sum of the latitudes being *B E C* (= 96° 26′.2), one-half the difference between 180° and *B E C* gives *E B C,* or *E C B.* Having measured *Z1 B M* and *Z2 C M,* the former added to *E B C* and the sum deducted from 180° will leave *M B C* in degrees, and the latter added to *E C B* and the sum subtracted from 180° will leave *B C M.* Knowing *B C M, C B M,* and *B C,* we solve the triangle by geometry, or better, by trigonometry, and obtain *B M* and *C M,* and finally *E M,* the desired distance from the moon to the earth.

Supposing the Berlin observer finds the zenith distance, *Z1 B M,* of the moon to be 53° 15′.1, at the instant that the Cape Town astronomer finds the zenith distance, *Z2 C M,* to be 34° 28′ How far is the moon from the earth; i. e., how long is *E M,* if the radius of the earth is 3,963 miles?

(To be continued.)

Metrology.

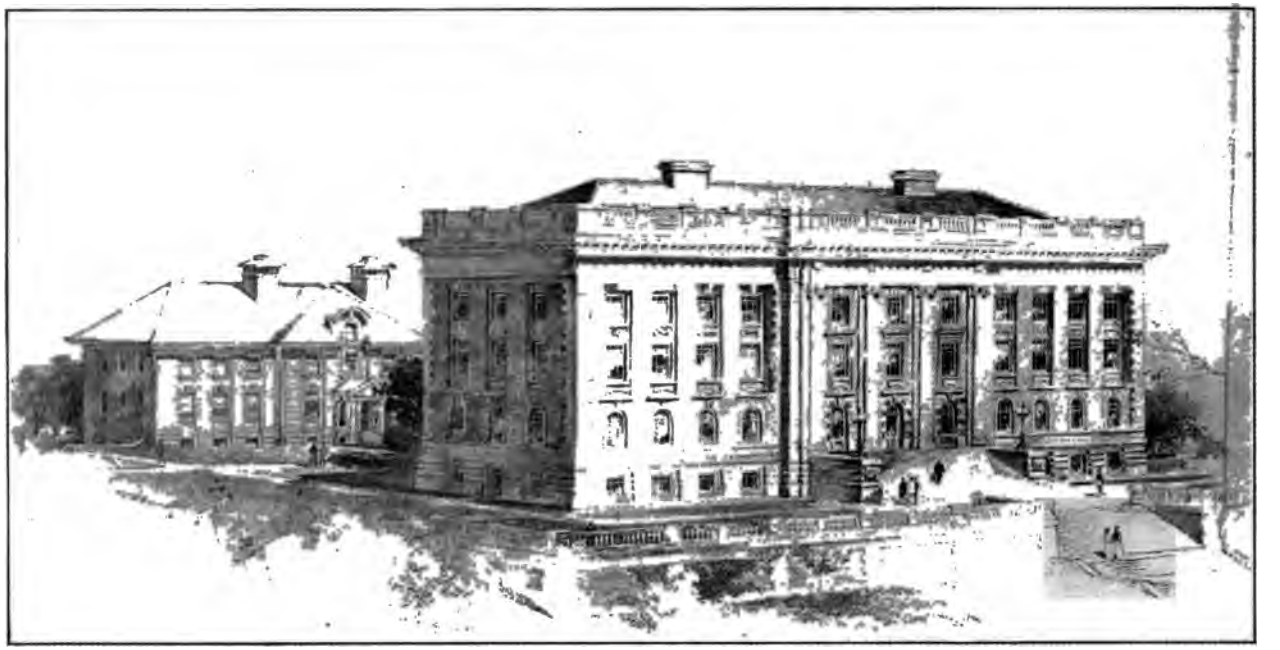
THE NATIONAL BUREAU OF STANDARDS.

BY RUFUS P. WILLIAMS.

This institution is one whose prospective value to exact science in America can hardly be overestimated. In creating it the 56th Congress passed an act which each succeeding year has rendered more necessary. In the early days of our history every colony had its own standards of weight and measure, which were later adopted by the various states. These standards differed widely. When the colonies became a nation, though the Constitution gave authority to Congress to make one uniform standard, and Washington in his first message recommended it, it was still left to the states. As there was no call for exactness and "pretty near" would then do for comparative measurements, there was no need of a bureau, hardly of a bureau drawer. But as soon as Uncle Sam began to do his own work a standard must be had, and this the Coast Survey first introduced.

Nothing came of Robespierre's effort—when in 1794 he sent over from France a copper meter stick and a kilogram weight of the same metal—to induce the United States to adopt the metric system. It was not till 1814 that a standard of length—the Troughton 82-inch brass bar—was brought from England, the distance between two lines on that bar being adopted for use as the yard in the survey of the coast. In 1821 the first platinum meter and kilo were imported, and in 1827 came the Troy pound, of brass, from England. This latter was the only one of all having the sanction of Congress.

The need of uniformity was emphasized in 1830 when the Senate ordered a comparison of the measures and weights at the various custom houses in the United States to be made, and found large discrepancies. Eight years later the Secretary of the Treasury was ordered to distribute to the governor of each state a set of all the weights and measures which he had adopted as standards.



THE NATIONAL BUREAU OF STANDARDS.

Then followed, in some cases, the passage of state laws confirming the government measures. In this manner was partial uniformity established. The passage by Congress of the metric act in 1866 and the distribution of metric weights and measures to all the states, was followed by the convention at Paris in 1875, and the founding in that city of the International Bureau of Weights and Measures, and in 1889 by the transmission to the United States of the national prototype meter and kilogram, which have ever since been the final appeal for length and weight in government work. These and other standards were kept in the Treasury Department, in the custody of the Superintendent of the Coast and Geodetic Survey, until July 1, 1901, when they were turned over to the Director of the Bureau of Standards.

With a century's growth of exact science the need of standards and standardizing apparatus has enormously increased. Instead of the pound, foot, gallon and bushel of our fathers—manufacture, trade and the arts of modern life demand the testing of such appliances as balances, weights, apparatus for the measurement of capacity and length, thermometers, pyrometers, meteorological apparatus, barometers, hydrometers, instruments for testing oils, sugars, alcohol and other liquids, also those used in navigation, surveying and hydrography, photometers, gas meters, wattmeters, volt and ammeters, magnetometers, speed indicators, steam-engine indicators, pressure gauges, graduated chemical glassware, apparatus for testing the strength and other properties of materials, etc. All these must be the refinement of accuracy, and must have skilled specialists to make and adjust them.

To the present time there has been no suitable place for keeping the few standards the government owns. The weights have been kept in a coal vault, subject to more or less moisture and temperature changes. The need of standardizing apparatus and of experts to direct the processes will be more apparent after considering half a dozen of the above cases.

(1) Take the graduation of thermometers and pyrometers. Such work is now done in Germany and England. In 1897 more than 100,000 thermometers were standardized in Germany. In the Kew Observatory in England some 18,000 chemical ther-

mometers were tested. We cannot do the work in this country now, but it will be one of the functions of the new bureau. As one single illustration of the value of precise measurements, the government saved $125,000 by being able instantly to know the exact change of temperature in the process of shrinking a jacket on a 16-inch gun. The need of such standards is increased by the very low and very high temperatures now made available in scientific work.

(*Concluded in May.*)

Notes.

CHEMICAL.

Berthelot.—A gold medallion was presented to M. Berthelot on November 24, 1901. The occasion was the fiftieth anniversary of his entrance into the laboratory of the College de France as a teacher. At that time he became an assistant to M. Balard. Addresses were made by scientific and public men. The medallion, which was designed and executed by M. Chaplain, was presented to M. Berthelot by President Loubet.

L. C. N.

A Simple Proof of Nitrogen in Nitric Acid.—Not feeling satisfied with the slowness and occasional failure of the proof of nitrogen in nitric acid, by the method of reduction to ammonia by zinc and sulphuric acid, and the detection of the ammonia by subsequent evaporation and the addition of sodium hydroxide, I have devised a modification of this method which I can recommend as rapid and certain in the hands of students.

The directions are as follows: Into a test tube put 4 cc. of water, add 12 drops of concentrated nitric acid and stand in the rack. Add a stick of sodium hydroxide 1 cm. in length and shake for a moment; then add successively several narrow strips of aluminum foil. Test the evolved gas for odor and for action on moist litmus and turmeric papers.

The reaction with the aluminum soon becomes violent. The whole experiment requires less than five minutes. The students are told before-

hand that hydrogen is evolved by the reaction of aluminum and sodium hydroxide, and they already know of what elements ammonia is composed.

Teacher of Chemistry, Waltham High School, Mass. OLIVER P. WATTS.

Formation of Sulphur Dioxide for Laboratory Students.—One of the stock experiments in the subject of sulphur is a study of the gas, sulphur dioxide. The text books direct that this gas should be prepared by acting on copper with hot concentrated sulphuric acid. Every teacher of chemistry appreciates that hot concentrated sulphuric acid should be accorded a considerable amount of respect and should be given to an elementary student with a good deal of caution. Personally, I know of three accidents from its use in the above experiment, two of them serious.

It has been my custom to prepare this gas by acting with dilute sulphuric acid upon crystals of sodium sulphite. The reaction is carried out in a flask, provided with a thistle tube, and a delivery tube for downward displacement. The acid should, of course, be added slowly.

The reaction involved here is easy to interpret, the danger of the old method is avoided, and my experience with it justifies me in recommending it to other chemistry teachers. It is a very small point, but one that may save trouble.

Boardman Man. Tr. High School, New Haven, Conn. S. P. BEEBE.

The Handling of Phosphorus by students is accompanied with so much danger that every precaution should be taken to reduce it to a minimum. By giving out the element already divided up into small bits, the students are saved the trouble of cutting off what they need from a stick of it, and the liability of fires or burns is much lessened. It is quite easy for the instructor to prepare a stock of phosphorus in the form of small globules, which are admirably adapted for students' use. A tall jar (hydrometer) is filled with hot water and the water kept quite hot by passing a current of steam into it. A supply of phosphorus is then placed in the jar, where it soon melts. An ordinary pipette, with a piece of rubber tubing slipped over its upper end, is put into the jar with its tip in the molten phosphorus, and then filled by suction with the element. The rubber tubing is pinched together and the tip of the pipette transferred to some hot water, gently placed upon some cold water, filling a second jar. This hot water, floating upon the cold, prevents the pipette from becoming stopped up by the solidification of the phosphorus. The phosphorus is then allowed to drop out of the pipette, and, as it passes into the cold water, it solidifies into flattened globules. These are transferred into a bottle, where the student can easily remove one when needed.

Book Reviews.

Invertebrate Zoölogy. By H. S. Pratt, Ph. D., Professor of Biology at Haverford College, Haverford, Pa. 16x27x2 cm., 210 pages. Ginn & Co., Boston, 1902. $1.35.

The feature which is characteristic of this book is, as stated by the author in the preface: "The plan of this course is to study each of the larger groups of the invertebrate animals, so far as possible, as a whole, instead of detached types of different groups taken more or less at random, as is usually done." In correspondence with this plan, ten of the larger groups, Arthropoda, Annelida, Platyhelminthes, Bryozoa, Mollusca, Urochorda, Echinodermata, Cnidaria, Spongiaria and Protozoa, are treated as separate and distinct wholes.

A chapter is given to each group. The number of animals treated in each group varies from one in Bryozoa, Urochorda and Spongiaria, to fourteen in the Arthropoda, the remainder of the groups being represented by from two to four types. The types are selected with a view to the proper presentation of the more strongly marked differences to be found in the animals of each group. Usually the lowest type is placed first, but in the treatment of the types, as well as of the groups, the idea of the author seems to be that the student is to get his idea of the rank of the animals solely by the comparison of structure, and is not to be guided or influenced by the arrangement in the book. The work on each type is almost purely anatomical, although some cases showing the relationship of structure to function are brought to the student's attention. While the structure is minutely given for each type, the characteristic features common to all of the types of a group are not pointed out, but are left for the student to discover.

The Arthropoda are given by far the greatest attention, because, in the author's words, "the natural succession of forms from the lowest to the highest is more apparent in them than in any other group of invertebrates, and it is, consequently, easier for a beginner, by studying them, to learn to appreciate the real significance of the blood relationship of animals."

One of the striking features of the book is the independent treatment of each type and group. Any one may be taken from the context and used successfully, because each is complete in itself. A teacher is able to pick out the forms which he considers best suited for his purpose, and use the manual directly without making any bridges or smoothing frayed edges.

In following the manual, the student is first told what to look for,

the names of the parts which he is to find, and where they are located, and then is required to make a drawing showing these parts and labeling them. The drawing and the dissection required are carefully indicated, at the proper places by "exercises" numbered consecutively, for each type. The typographical arrangement is very good, frequent paragraphs, names of parts in bold-faced type, with the proper titles for the paragraphs, also in heavy type. There are, very properly, no drawings of the animals studied for students to copy.

While in the body of the book no indication of the rank of the various groups in the animal kingdom is stated, in the appendix is given Claus' classification, of phyla and classes, with a brief historical sketch of past classifications. There is also a valuable table of phyla, and minor divisions, going as low as orders in most cases, with a very brief definition of each. A rather complete glossary is given.

Omaha High School. H. M. BENEDICT.

Physical Laboratory Manual. By WILBUR A. FISKE, A. M., Instructor in Physical Science in the Richmond High School. 14x20 cm., 183 pages. Nicholson Printing & Mfg. Co., Richmond, Ind. 1901. 75 cents.

This attractive manual contains directions for the performance of 93 experiments, which the author's experience warrants him in choosing as suitable to high-school conditions. Also in an introduction there are given brief but clear directions as to note-books, errors and the graphical representation of data. Most of the exercises are quantitative in nature and of such a nature as to give accurate results, if properly performed. The author has very commendably been at considerable pains "to use simple language and to describe carefully all the details in the course of experiment." He also insists throughout upon a good tabulation of data, the use of the metric system and the graphical representation of data, whenever possible. Some teachers of physics would wish an exercise or so with the Jolly balance and some emphasis upon the use of a d'Arsonval galvanometer, but, taken all in all, the manual is certainly an excellent one and well adapted to its purpose.

C. E. L

Reports of Meetings.

NEW YORK CHEMISTRY TEACHERS' CLUB.

The Club was organized at a meeting held at the Hotel Albert, New York City, March 20, 1902, and the following officers elected. A. C. Hale, president; R. H. Fuller, vice-president; M. D. Sohon, secretary; A. A. Arey, treasurer.

The Club is composed primarily of teachers of chemistry in secondary schools, and desires to reach all such teachers within the metropolitan district.

Reported by M. D. SOHON.

NEW YORK PHYSICS CLUB.

The seventeenth regular meeting of the Club was held in The Cutler School, New York, on Saturday, March 15, 1902. After the routine business, the report of the committee on "Physics in the New Course of Study in the Boroughs of Manhattan and Bronx" was presented and discussed at length. As this course will probably be adopted by the whole city, the following resolutions were passed. (I) That it is the opinion of this club; (*a*) that five periods weekly in the third year should be given to physics; (*b*) that one of these periods should not require a prepared lesson; (*c*) that when circumstances permit, one of these periods should be of double length and given to laboratory work; (II) that it is the opinion of the club that advanced physics should be offered as an optional study of the fourth year.

It was decided to form a photographic section of the club, which should have for one object the preparation of a set of lantern slides relating to physical subjects, this set to be the property of the club and loaned to members. Under the leadership of Mr. J. M. Jameson, of Pratt Institute, there were discussed the methods of teaching four laboratory exercises—the parallelogram of forces; conjugate foci of a lens; latent heat of vaporization; Boyle's law.

Mr. Henry S. Curtis, of the Boys' High School, Brooklyn, showed an ingenious device for determining the conjugate foci of a lens. It consisted of a frame for holding a meter stick with a piece of tin at one end in which were cut two holes. Across these were soldered two pieces of wire, thus furnishing the object whose image was formed on a sliding card. Prof. E. H. Hall spoke of several devices which he had found helpful.

After lunch Prof. Hall delivered an address on "The American Physics Teachers' Opportunity," which appears in full on page 57 of this number. After a discussion of Prof. Hall's address, the meeting adjourned.

Reported by R. H. CORNISH.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The thirteenth meeting of the Association was held on Saturday, February 1, 1902, at the American House, Boston, Mass. After the transaction of the usual preliminary business, the annual report of the secretary, Mr. F. W. Howe, was read. It showed that the total membership is ninety-six, thirty-seven being associates. The annual report of the treasurer, Mr. E. F. Holden, showed that the Association is in good financial condition. A vote of thanks was given the L. E. Knott Apparatus Company for their courtesy in printing the List of Books in Chemistry. Twenty associate members were elected.

The main portion of the meeting was devoted to reports of all the committees. The Committee on New Apparatus, Mr. I. O. Palmer, chairman, described, by means of samples and diagrams, the simple operations of glass-working, the purification of mercury, and a new thermometer. Dr. Lyman C. Newell, chairman of the Committee on Reference Books, called attention to Blount's Electrochemistry, Remsen's College Chemistry, Ladenburg's Lectures on the History of Chemistry Since the Time of Lavoisier, Prescott and Johnson's Qualitative Chemical Analysis, and Benedict's Chemical Lecture Experiments. Mr. Wm. H. Snyder, chairman of the Committee on High-School Study, presented a personal statement of the difficulty of meeting college requirements in chemistry. It was not a formal committee report, and was made largely to bring out the sentiment of the meeting. The general feeling seemed to be that the subject demanded a more extended consideration than the limited time of the meeting permitted.

Dr. H. G. Shaw, for the Committee on Physical Chemistry, reported the results of recent work in this field. Dr. Charles A. Pitkin, chairman of the Committee on Physiological Chemistry, read abstracts of recent articles in this branch, calling attention especially to the work on food and nutrition being done under the direction of Prof. W. O. Atwater; one interesting abstract was devoted to the manufacture of indigo. The Committee on Chemistry as a College Entrance Subject reported through its chairman, Dr. Lyman C. Newell, that the work accepted by the colleges, though not uniform, laid stress on laboratory work and on certified note-books, and, on its own recommendation, the committee was authorized to continue the investigation and report later; in the report attention was called to the fact that the college authorities were exceedingly courteous and manifested great interest in the attempt to secure mutual understanding. Mr. Charles R. Allen, chairman of the Committee on Laboratory Construction, read the proof of a set of questions soon to be circulated with a view to securing accurate data for the construction of the best possible laboratory. The Committee on Current Events reported through its chairman, Dr. Lyman C. Newell, that over fifty articles had been abstracted; attention was briefly called to

the Berthelot anniversary, the work of Moissan on fluorine, and a description of the laboratory of Ostwald.

After dinner there was a symposium on the topic, "How can the efficiency of our Association be increased?" The speakers were Miss Laura B. Patten, Messrs. George A. Cowen, Lyman G. Smith, and Oliver P. Watts. Many of the suggestions were of interest solely to the members; those of general interest were the instituting of a question box, trips to see industrial operations, the desirability of keeping in touch with colleges, the advantages of holding meetings in school laboratories rather than halls or hotels; all the speakers emphasized the value of cooperation and good fellowship.

The meeting was well attended, and the reports, though numerous, were suggestive, profitable, and stimulating.

Reported by LYMAN C. NEWELL.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION. SECTION OF BIOLOGY.

(Continued from page 53.)

Henry R. Linville, DeWitt Clinton High School, New York, Chairman

The following men presented papers: Prof. F. E. Lloyd, Teachers' College, Columbia University, New York, "The Preparation of Secondary Teachers in Biology." Dr. A. J. Grout, Boys' High School, Brooklyn, N. Y., "What the Teacher of Botany in Secondary Schools Should Be Prepared to Do." Prof. A. D. Morrill, Hamilton College, Clinton, N. Y., "Ideals in Teaching." Prof. N. A. Harvey, Chicago Normal School, Chicago, Ill., "The Training of a High School Teacher of Science."

THE PREPARATION OF SECONDARY TEACHERS IN BIOLOGY.

(Abstract of Professor Lloyd's Paper.)

Of the pupils found in the high school, but a very small proportion pass beyond into the college. The high school is then the "college of the people" in a very wide sense, and is worthy of the very best efforts of well educated and highly trained teachers.

At the present time the high school is supplied with teachers who have been prepared for their work either (a) in normal schools, or (b) in colleges and universities, but without the opportunities for professional training.

It is maintained that the preparation of both these classes is inadequate. The former class has had the advantage of distinctly professional training, but has been handicapped by an insufficient equipment in the subject matter, and has brought elementary and grammar school

methods into the high school. The latter class has done the same with university methods. The result, in part attributable to these conditions, is a great lack of uniformity in ideals, a marked unevenness in the quality of instruction and a remarkably heterogeneous high-school course, taking the country as a whole.

The plea, therefore, is made for the special preparation along distinctly educational lines of those who desire to fit themselves for the profession of secondary teaching in biology. Such should hold the bachelor's degree, and during their college course should have studied physics and chemistry. In biology they should have earned at least nine points credit, of which no less than one-third should be in botany or zoölogy, preparatory to entering upon professional study.

In addition to general courses in psychology and in the history and principles of education, the professional training should consist in:

(1) A more specialized study of secondary education which should acquaint the candidate with the general problems of the high school.

(2) A course in the theory and practice of teaching biology in secondary schools. Such a course naturally divides itself into two parts.

(a) A theoretical part, consisting of lectures and collateral reading on the history and aims of the teaching of biology, on the course of study, including the plan of the course and the choice of topics and materials, and other cognate topics.

(b) A practical part, consisting in the observation of teaching in secondary schools, in the construction of a course of study, in a study of available materials and of many other allied matters. The practical work should culminate in a season of actual teaching under skilled criticism, the chief value of which is to be found in the experience gained by the practice teacher.

The candidate should, at the same time, be pursuing advanced work in both botany and zoölogy.

Such a course may well be made to lead up to the conferring of diplomas coördinate with the degrees of special schools, as of law and medicine, and equal to them in significance. For the higher diplomas (Master's and Doctor's), a corresponding amount of research of a sustained and original character, in the field of education, should be required.

IDEALS IN TEACHING.

(Abstract of Professor Morrill's Paper.)

At one time or another, since the modern teaching of natural history can be said to have begun, various ideals have dominated the presentation of that subject. First, taxonomy held sway, then the study of types, and later the investigation of physiological processes. With the increase in the extent of the knowledge of plants and animals along the lines of adaptations, evolutions, embryology and ecology, however, the identi-

fication of these ideals becomes more and more difficult, until now we find no single ideal in vogue; anything that may exist must be more or less broad and inclusive in character.

Existing at the same time with the more or less clearly conceived general ideals, there have grown up out of experiences in class-rooms and laboratories, and from influences outside, minor ideals which, in many instances, are of an extra scientific nature. Trimming the principles of biology to meet the exigencies of a set of examinations is a spectacle very often witnessed in our midst. An impression that sometimes creeps into schools from the outside leads pupils to think that the study of plants and animals is of no serious consequence, and it does not pave the way to financial profit. Such an ideal, although not held by the teacher, dominates the teaching unless the teacher, by the substitution of a higher ideal, is able to submerge the less worthy one.

In elementary work the pupil is of much more importance than the subject, but many university-trained men, when they do not consider teaching a bore, are apt to be more concerned with presenting their subject symmetrically than they are with the problem of creating in the minds of their pupils a liking for science. A similar blindness to proper methods of learning is to blame for the method employed sometimes by those who dull all the interest of discovery by giving preliminary lectures and demonstrations, making the laboratory period one of uninteresting verification.

Of all the ideals of practical teaching in biology, the one best calculated to help the young pupil to break away from the dominating authority of books is that which leads him into the paths of nature in such a way that he will come upon the truths himself. This may be done without employing the extreme method of Agassiz. The object of teaching is not to get rid of the weaklings. The average pupil needs judicious guiding rather than to be left to his own resources. As the pupil advances, however, more and more must be expected of him.

The influence of well-guided work in biology is not more noticeable than in the development of individuality. The habit of being independent in judgment grows, and so powerful has it become that frequently an excellent instructor is not more successful in bringing the indifferent workers into line than is the example of a single earnest, interested and independent member of the class.

THE TRAINING OF A SCIENCE TEACHER FOR SECONDARY SCHOOLS.

(Abstract of Professor Harvey's Paper.)

A teacher of science in a high school ought to know three things: first, his subject; second, the psychological movements involved in learning the subject; third, the principles and the art of teaching.

A knowledge of the subject matter of a science is of primary import-

ance, because it constitutes the instrument with which the teacher does his work. Without such an instrument perfected to the degree possible before and during the teaching experience, no substantial progress can be made. Although it is true that, other things being equal, the more thorough a teacher's knowledge, the greater will be his success, there is always the danger of pursuing a line of research to the detriment of the proper growth of certain personal qualities. Unfortunate as such a one-sided development would be in the teacher, the result would be disastrous to the intellect of his pupils, should he attempt to drill them in the methods of the trained investigator.

If the teacher succeeds in avoiding the use of men's methods in trying to develop children's minds, it will be on account of his having more than a theoretical knowledge of the general laws of mental action. He must know how to bring the mind of a child into the presence of the subject-matter in such a way that its activity will be aroused, and growth result. The possessor of ability of this kind is no longer a mere scholar; he becomes a real teacher. He is no longer an artisan; he is an artist.

Granting, however, that an ideal teacher is not the result of chance, there comes the recognition of the necessity for preparation. While it is true that what the ordinary normal schools undertake to do for the grade teacher should be done for the high school teacher, it is not possible, under prevailing conditions, for the normal schools to train high school teachers properly. On the other hand, colleges and universities do not offer an ideal preparation for the teacher of science. The college-trained teacher is very likely not to be a teacher at all, having been occupied throughout his course with the idea of storing up knowledge, and that with little or no consideration of the psychology of the process. Neither is it likely that few men just out of college seriously discuss with themselves the question of the possibility of a difference in the methods necessary to teach children, and those employed to instruct them.

There are three alternatives by which better trained teachers may be secured. First, normal schools may modify their constitutions in order to meet the demands for high school work; second, universities may alter their courses in pedagogy so that there shall not be the entire absence of practice in teaching from the discussions of the theory of education; third, the teacher may get this knowledge of his special subject in the university or college, and his pedagogical training in the normal school. The last alternative seems likely to prove the best, especially if the normal school work precedes the university training, for when the prospective teacher is grounded in the principles of teaching he is able to see what is involved in particular methods, and he is able to criticize intelligently the materials and methods offered in universities.

Reported by HENRY R. LINVILLE.

MICHIGAN SCHOOL MASTERS' CLUB.

CONFERENCE OF THE BIOLOGICAL SECTION.

Two sessions were held, Friday afternoon and Saturday forenoon, March 28th and 29th, the latter being a joint session with the Michigan Academy of Sciences. Both sessions were well attended.

After calling the meeting to order and making some announcements, the chairman, Mr. L. Murbach, made some remarks on the proposed amalgamation of the biological section with the Michigan Academy of Sciences. He said the biological section would better not surrender its identity by fusion with the Michigan Academy of Sciences, but that the Michigan Academy of Sciences might form a science teaching section which the members of the biological section could join, leaving them the opportunity to hold their own conference at any time when the Michigan Academy of Sciences meets at a different time or place from the Schoolmasters' Club. He pointed out the advantages of the union as, membership in the larger body, opportunity to hear purely scientific papers, and the right to the publications of the proceedings. Pending the action of the Michigan Academy of Sciences, the Conference proceeded with its program.

A summary of each paper follows, and some will be more fully presented in later issues.

Mr. Ray A. Randall, Assistant Principal, Goshen (Ind.) High School, gave the first paper on "The Relation of Nature Study to High School Biology." He showed the importance of guiding the child through the grades so that he is in position for independent thinking. Nature study stimulates the mind to its fundamental activities and supplies it with elemental material for thought. Attempts to introduce nature study in the grades have failed because the science work is left to the grade teacher. A person who can lead others is needed, a specialist born a naturalist. A special teacher can handle from three to five grades, giving six hours a week to a grade, by devoting three periods of two hours each to a grade. An important prerequisite in the pupil is love for nature. Nature study does not aim to make specialists, but to educate, to form proper habits. Plants and animals should not be personified or endowed outright with motives. Technical terms, when needed, will be learned as easily as are the words of a foreign language. The pupil who has not had nature work in the grades has to reconstruct his habits of study and thought, and instead of having a student in biology, the high-school teacher has in him a beginner in nature study.

In opening the discussion of the paper, Miss Gertrude Gillmore, of the Washington Normal School, of Detroit, contended that, while especially trained science teachers are necessary to organize and conduct the work, yet the grade teacher is better fitted to teach the child directly, as

she is more familiar with his environment and capability. In answer to the suggestion that the grade teacher is generally ignorant of what to teach and how to teach it, Miss Gillmore responded that she is to take up each subject a month beforehand and do a little at a time under the guidance of the special teacher, until she is prepared. Miss Gillmore then explained her method of conducting such work. Both speakers advocated biological material for nature work rather than minerals or physical phenomena, that are sometimes introduced.

In the next paper, "The Relation of Laboratory, Field, and Recitation work in Biology," Miss Frances L. Stearns, Adrian, held that the laboratory method has proved itself the natural and substantial basis of high-school courses in biology, and that the well-equipped laboratory is either a part, or the legitimate demand, of every high school. About half the time may be given to the laboratory work. The morphological and physiological work that has been done almost solely heretofore, fails to give a pupil first-hand knowledge of plants and animals in their homes, and the relationship between living things and their environment. Though field work, as a method of instruction for high-school pupils, is in its experimental stages, it can and should give the boy his first key to nature—the "what," then the "why," as far as possible. The hindrances to good field work are the teacher's own lack of knowledge or lack of method in using what is known, lack of time, and the ordinary hindrances to making extended trips with large classes. Class-room discipline should not be attempted. Competitive gardening lays a good foundation for field work. Pupils may be prepared for a field trip by talks, carefully prepared questions, and short excursions in the neighborhood. * * * * The recitation is the important supplement of the laboratory and field work, correcting errors and fixing the results. It should not be the place to give information, but to express what has been learned, to classify, and deduce principles.

Following this, Professor Chas. A. Davis, of the University of Michigan, on the "Possibilities of Field Work," emphasized points made in the preceding paper, and contrasted past with present methods. He said all the difficulties of field work are no more fundamental or valid than the objections formerly urged against the laboratory method. The possibilities of field work are great when (1) teachers will prepare for it as they do for other kinds of work, by constant study of the region in which they teach; (2) the size of class sections taken to the field is small, not exceeding twenty; (3) the work is carefully planned and pupils are properly guided and watched; (4) the classes are questioned as to what they see, and are not simply told what the teacher sees; (5) when the special object of the exercise is coördinated with other related topics by questions and suggestions. Possible lines of work in botany, zoölogy, geology and physiography were then suggested, and teachers

who have to do this sort of work with their classes and hope to be successful were urged to take up field work for themselves.

In the discussion following, it was evident that the majority of teachers did field work only as a side issue, and that this subject should be further developed; that 25 was as large a number as could be profitably taken at one time; that in cities much can be done in the parks; with large numbers it is better to have written directions or questions; that a successful way of doing field work is to take only the most interested students.

Acting on a suggestion previously sent in by Professor S. O. Mast, that it would be desirable to have a set of experiments in Plant Physiology, the chairman appointed a committee to formulate a set of such experiments, with suitable apparatus, for a half or a whole year's high school course.

A paper from Miss Grace Ellis, of Grand Rapids, on "Physiology as a Science Study in the High Schools," made the following points: The optimum and logical preparation for physiology would be that botany, zoölogy, chemistry and physics should precede it. In case it cannot be preceded by these, simple experiments in chemistry and physics must be made in order to make the subjects in physiology comprehensible. Here is the starting point. In the laboratory, guided only by a sheet of directions and tested by questions, the learner finds out something of the composition of his own body. This introductory work may be followed by a set of simple experiments on acids and alkalies, then by tests for foods. The study of foods is followed by that of digestion, circulation, respiration, excretion, in order, ending with the study of the nerves and ganglia, especially as seen in the frog. All these are studied experimentally first. Physiology, hygiene, and sanitation should be the interpretation of the simple physiology of our course of study. It is desirable that there be a widespread understanding of the nature of contagious diseases in order that the action of medical boards and boards of health may have a meaning in the minds of the public at large. The creation of such an understanding seems to me an important duty of the public schools.

Mr. Raymond Pearl, of the University of Michigan, then read a paper on "Practical Physiology in the High School." He said in substance: Physiology, as taught in the average high school, is open to criticism from three general standpoints. These are: (1) high-school physiology comprises for the most part something other than true physiology; (2) its purpose is too largely one of attempting to impart a concrete knowledge of the human body, without regard to general training; (3) the method of presentation to the student is faulty for two reasons. First, in that the most complex rather than the simple is taken as the starting point; and second, in that the subject is presented dogmatically, i. e., as something finally known.

The most important things which will contribute towards the elevation of high-school physiology to the level where it ought to stand are: (1) the use of a rational laboratory method for the purpose of developing the student's general mental powers; (2) the presentation of the subject as a living affair to be investigated, not something dead to be memorized; (3) the substitution of the standpoint of "general physiology" for that of "organ physiology;" (4) the presentation of something of the historical development of the science as a practical means of holding the student's attention.

The program closed with a paper by Dr. H. S. Jennings, of the University of Michigan, on "Some Biological Problems." As it is expected that this will appear in full in a later issue of SCHOOL SCIENCE, no abstract is given.

At the close a resolution was offered that, as physiology in its broader sense is one of the biological studies and may, if properly taught, be made of equal value with any other, it should justly be recognized by university authorities, and that such recognition would promote its better teaching.

Reported by L. MURBACH.

(To be continued.)

Correspondence.

ALCOHOL A FOOD?

EDITOR SCHOOL SCIENCE:

The researches of Atwater and others on the food value of alcohol have caused much commotion among the teachers of temperance. They have for so long a time based their principal argument against alcoholic beverages on the dogma that alcohol is, at all times and under all conditions, a most deadly poison, that anything contradicting this statement is greeted as rankest heresy. "Once a poison, always a poison," seems so self-evident.

I think it might, therefore, be of value if it is pointed out that some of the simplest, most harmless substances of daily use possess this same property of being at one time beneficial, at others injurious. The most striking example of such a substance is sodium chloride. It is present in every tissue of the body, is a constituent of every animal and vegetable food, and is necessary for digestion and nutrition, even for life itself.

Yet, in spite of this, sodium chloride is used in certain countries as a cheap but sure means of suicide. The Chinaman, bent on self-destruction, swallows large quantities of a strong solution of it. When so taken it is the deadliest of poisons, producing the most acute intestinal inflammation and all the other horrible symptoms of poisoning with corrosive sublimate. Death results after untold agonies.

Ordinary table salt is, therefore, both a poison and a food; a poison in large amounts, a most valuable food in smaller quantities. That alcohol, in minute doses, may have a real food value should not, therefore, be so unthinkable, and the sooner the teachers recognize this and base their arguments against the abuse of alcoholic beverages on surer grounds—and there are, alas, enough of them—the better it will be for the cause they advocate. The greatest truth will suffer if supported by a falsehood.

Johns Hopkins Medical School. W. H. Manwaring.

FORMULA FOR AQUARIUM CEMENT.

Editor School Science:

The following formula was handed to me by a local merchant. It has proved very satisfactory in an aquarium made of plate glass, holding more than a barrel; so I am pleased to hand it on:

Mix 4 ounces coal tar, 2 ounces linseed oil and 1 pound rosin; boil slowly until a portion put into water at the temperature of the room, in which the aquarium is to be kept, becomes hard. If too hard it may crack; if too soft it will run. Apply while hot.

This preparation has a decided advantage over putty, made by mixing whiting with white lead, in that it can be used immediately after being applied, while putty must be allowed to dry a few months before being used.

In the above aquarium the glass was set with a little putty between the glass and the frame, and the cement preparation was put on the inside along the angles and on the bottom.

Hope College, Holland, Mich. S. O. Mast.

School Science

VOL. II] MAY, 1902. [No. 3

PROFESSOR REMSEN ON THE TEACHING OF SCIENCE.

BY LYMAN C. NEWELL, PH. D.

The Twentieth Century Club of Boston, Mass., provides a course of lectures each winter for the benefit of the teachers of that city and vicinity. President Ira Remsen of Johns Hopkins University recently delivered a lecture in this course on "The Place and Function of Science in Popular Education." The lecture was a lucid exposition of this teacher's views on science teaching in general and on the teaching of chemistry in particular.

In answer to his first question, "What distinguishes science studies from other studies?" he said:

"Science studies are, or ought to be, distinguished from other kinds of studies by the fact that they bring the pupil into direct contact with the things or phenomena he is studying. He is called upon to use his own eyes and his own mind. There is a direct connection between statements he may make and facts that he knows to be true as a result of his own experience. In their first stages, in their simplest forms, this should be the most prominent feature of science studies. Any course of study that depends largely upon what a lecturer may say or upon what a pupil may read in a book can never be a science course, no matter what the subject, no matter how good the lecturer, or how good the book. The essential feature of direct contact is lacking. So also the emphasizing of the theories of a science, no matter how important those theories may be or how well they may be established, should not play an important part in a science course in its early study. As far as this fact is lost sight of, the course is not scientific. It is not scientific, for example, to present and discuss the atomic theory in an elementary

course in chemistry, or the electro-magnetic theory of light in an elementary course in physics, or the nebular hypothesis in any course. The pupil must first learn how knowledge is acquired by direct contact. This lesson must be impressed upon his mind before he can profitably take up the profound thoughts to which scientific investigators have gradually been led—thoughts which are based upon an immense accumulation of facts learned by direct contact."

He then showed how language, mathematics, and history do not meet these tests, and are therefore not science studies. Much to the amusement of his hearers, he then said that many science courses—so-called—would not meet this simple requirement, viz., the element of direct contact. "They are mere masquerades," he said.

In answer to his second question, "What ought science studies to accomplish?" he said in substance:

"It is often stated that the object of science studies is to develop the power of observation. This is true, but it is far from being the whole truth. There are other ways of developing this power, perhaps better than by pursuing elementary courses in science. Life on a farm or life out of doors tends in this direction. The savage probably has the keenest powers of observation possessed by any member of the human race. He gets his knowledge and his power, not by studying books, but by direct contact with the things around him; that is, by the scientific method. Science courses should teach more than the power to observe. They should teach how to draw conclusions. They should lead to a scientific state of mind. By this is meant a state of mind that enables the possessor of it to take the most direct course in dealing with any problem that may be submitted to him; that enables him to see through the mere talker, through the shams, and go back to the facts and draw his conclusions from them; that enables him to discriminate between what is known and what is imagined. That state of mind called *unscientific* might be described as the average state of mind, that state of mind which accepts popular superstition or which has undue willingness to talk much on topics little understood."

As to how far science courses accomplish what they are designed to accomplish, he said: "Not far, but it is better to get a glimpse than no look at all. Probably the average course of science does comparatively little toward putting the pupil in a scientific state of mind. Still, if this kind of study is right in principle, and in regard to this there can probably be no doubt, the pupil ought to have at least a taste of it. Some pupils will, of course, be much more benefited than others. Some will be inspired by this kind of work. No one can be harmed by it. If the courses were what they ought to be, then all the pupils ought to be, and probably would be, benefited by them. The ideal course is one in which the pupil makes daily observations, spends a certain amount of time in reflecting upon what he has observed, and then from time to time is led to see the connection between his own observations and some of the important generalizations that have been reached, which, taken together, form the ground-work of the sciences. The usual results of a year's work in chemistry are meagre." He then illustrated this point by some answers received by him from entering students.

He gave many practical suggestions in answer to the question, "How can science courses be improved?" saying substantially:

"The greatest need is that the courses be made more scientific. Everything that is labeled scientific is not necessarily scientific. Indeed, some of the most unscientific courses I have ever known have been called scientific. Studying chemistry by listening to a lecturer and seeing him do things, or by reading a book, may be scientific as far as it goes, but is more likely to be more unscientific. Even experimenting in a laboratory is not necessarily scientific. Imperfect observations of complex phenomena, and the writing of statements supposed to be based upon what has been seen, but really drawn largely from the printed laboratory guide—these processes are not scientific, and they cannot lead to good results. They are more likely to do harm than good, as they involve waste of time and give false impressions in regard to scientific methods. Nor can the best work be accomplished by turning the pupil loose in the laboratory and letting him experiment without supervision. The questioning teacher is necessary in order that

good results may be reached. The teacher has here a splendid opportunity. Questions in regard to work done in the laboratory are of much more value than questions on matters studied from books or heard in a lecture room. The proper guidance in the laboratory demands the constant attention of the teacher; and, further, the teacher must have a full appreciation of what is meant by the scientific method. Such teachers are rare, whether in school, or college, or university. Undoubtedly the teachers of languages and mathematics are, in general, better fitted for their work than the teachers of science. It seems to me that what is most needed in our science courses is greater simplicity. The simpler phenomena should be studied so that the pupil's mind may be able to cope with the things he sees. The thoughts presented to him should be simple. He should be made to understand what he is doing and what he is talking about. If he shows a tendency to use words or symbols without being able to explain what he means, he should be corrected, just as if the subject were language or mathematics.

In regard to the laboratory work, which must be the basis of science courses, more care should be given by the teacher to secure *good* work. The pupil should be compelled to avoid slovenliness. A bad piece of apparatus is as bad as a bad piece of grammar or a bad mathematical demonstration. And in telling the story of his work, orally or in writing, the pupil should be held responsible for faults in language as well as in observation. Accuracy is an important feature of scientific work, and this the pupil should be led to feel."

The lecture was enlivened by many witty remarks. For example, "atoms are not fit food for infant minds," "some people don't suppose you have to have any facts to get up a theory," "a book with no reference to the atomic theory would never sell," "let the pupil observe and then observe him," "the most accurate language is the most scientific," "once it was all atoms, now it is all ions," "pupils are too ready to say 'haven't had that yet.'"

These thoughts have been reproduced from very brief notes in the belief that the readers of School Science may find them helpful in daily work.

CHEMISTRY IN EDUCATION.

BY C. L. SPEYERS.
Professor of Chemistry in Rutgers College.

(*Concluded from page 75.*)

The work in qualitative analysis will occupy about a year. In the case that general chemistry precedes qualitative analysis, the time given to the latter can be lessened, and the first part of the second year given to general chemistry, so that the latter may have somewhat over a year. For general chemistry in the laboratory, I look upon as very important. It is the study of the elements without particular attention to their detection and to their quantitative separation.

The experimenting involves the construction of apparatus, and this is a part of experimental chemistry that is of exceeding importance. The manipulations of analytical chemistry are in general very simple, not calling for any particular skill beyond that needed to avoid mussiness. As Professor Chandler of Columbia University used to say to his classes, "Anyone can be taught analytical chemistry. I could take the janitor and make an analyst out of him." With experimental chemistry the matter is different; experimental chemistry teaches constructive ability. It is by no means a simple matter for a beginner in experimental chemistry to put together a piece of apparatus for preparing moderately pure hydrogen, and if hydrogen is to be prepared as pure as possible, the necessary apparatus would tax the skill of the best chemists, far beyond that of the ordinary analytical chemist. Glass working itself is an art, and yet the research chemist must be acquainted with it as a very essential part of the construction of apparatus. I suppose it would be possible to run to the glass blower for every piece of apparatus designed, but it would certainly be highly inconvenient, exhausting, and involve a large part of the active hours, and the cost would be very great, particularly since the apparatus finally adopted is seldom like that first planned. Even for the student who does not propose to follow chemistry as a profession, a

practical knowledge of glass blowing implies valuable manual training; it implies a delicacy of touch that is useful in more ways than one. Moreover, the ability to construct a piece of apparatus in just the right way without makeshifts of cork and rubber often makes the difference between the success and failure of an experiment. So I would insist right at the beginning on clean, accurate fitting of just the right apparatus; very seldom should any makeshift be allowed. The rest of the experiment will then in many cases take care of itself. In the case of beginners, I would say, better an unsuccessful experiment with good apparatus than a successful one with badly constructed apparatus. A careful examination will soon show why an experiment fails, and a repetition brings success when the apparatus is properly constructed, whereas a badly constructed piece of apparatus may bring success once in a while, but is sure to bring failure often.

Dirty work is supposed to have been cured in the preceding analytical course, but if the general chemistry precede the analytical, attention must be given to cleanliness. To some extent slovenliness cures itself in an analytical course, for a slovenly student will find that his mistakes are far more numerous than those of his companions who are neat. Still, an analyst can have his beakers, flasks and test tubes clean inside, but dirty outside, and his desk sloppy. This must be prevented as much as possible; it shows a lack of appreciation of the fitness of things, a lack of æstheticism, and æstheticism is by no means unimportant in scientific work. We find few successful men who are slovenly, and we all know the difference between a well written, neat letter and a carelessly written and blotted one. These things being all right, the next test is the getting of the desired substance, say sulfate of iron, ferrous sulfate. Then the quantitative yield. Does the student get all that he should, all that corresponds to the iron used? If he does not, within certain limits which will vary for each substance obtained, the experiment is to this extent bad, or perhaps a failure, and should be repeated. The preparation must also be pure, and here a previous knowledge of qualitative analysis will be very handy.

Parallel with this work should run a course of lectures on

general chemistry in a more detailed way than in the course of the first year, provided the first year was given to qualitative analysis. When general chemistry is the work of the first year in the laboratory, then the lectures at the beginning may be more detailed.

At the end of experimental chemistry, the student will be ready to take up quantitative analysis. I am not in favor of spending much time on this subject. Accuracy is taught more emphatically than in the preceding branches of chemistry, but it hardly broadens the knowledge of the student. There is too much routine work to justify any prolonged study for anyone not intending to become an analytical chemist, and even for him it is very questionable whether a larger knowledge of inorganic and organic chemistry would not be better than more detailed acquaintance with quantitative analysis. The methods of the latter are so apt to change. As soon as the student has gone through with the principal operations, which can be learned by making a dozen analyses or so, and requiring five or six months, I would pass on to organic chemistry. This is not the view that used to prevail, and perhaps would still call out some protest. Quantitative analysis used to be considered the ultimate object of the chemist, but with the recent advances in carbon chemistry and in physical chemistry that notion is passing away. In connection with quantitative analysis should go the theory of the balance and the calibration of a set of weights. A short lecture course on quantitative analysis should accompany the laboratory work. And this finishes the analytical work of the course.

Lectures in organic chemistry should begin right after the first series of lectures in inorganic chemistry has ceased, for to have a good theoretical knowledge of organic chemistry before beginning the laboratory work is very advantageous. Much attention should be paid to carbon chemistry or organic chemistry; it is of great importance and well organized; outside of physical chemistry, the best organized branch, but unfortunately only so in theory. In practice there is much to be desired. Comparatively few carbon compounds react in a sharp, well defined way, in the way that most of the inorganic substances react. Much experience and

judgment is needed in working with the compounds of carbon to carry many experiments to a successful end, so we have no satisfactory theories to account for such peculiar behavior. So that a very different faculty is developed by the experimental study of carbon compounds. Quantitative relations and purity of preparation are to be the leading criteria of an experiment in carbon compounds. The manipulations are in general very simple.

The majority of the common reactions of liquid and gaseous inorganic substances take place so rapidly that it is not possible to directly detect any time law nor any other law concerning the active substances during the time that they are reacting. But with carbon compounds this is not so; the reactions proceed in general slowly; rapid reactions with carbon compounds are apt to be of the nature of explosions. Wherefore that branch of chemistry which has for its field the investigation of what happens during a chemical change did not develop rapidly until after a large development of carbon chemistry. The most important theories of physical chemistry are based on the properties of carbon compounds, and so carbon chemistry forms a very fitting introduction to physical chemistry.

Wherever physics may be brought into the course, it is essential that it precede physical chemistry. And the mathematics will, of course, precede the physics. The old method of teaching mathematics for the chemist is undergoing a change. More than one book has been written on calculus, differential and integral, in which the geometrical illustrations have been replaced by physical and chemical illustrations.

Physical chemistry is the science of investigating chemical changes by physical methods. It seems, therefore, almost self-evident that before physical chemistry can be studied, the chemical phenomena to which it applies must first be studied. And this seems to me to be the proper view to take; yet, since physical chemistry has organized chemical activity in a remarkable degree, it is now possible to present some general notions of physical chemistry right at the beginning of the study of chemistry, in the first year. But I do not think it advisable to do so; for the above reason and because there is some uncertainty as to the correctness

of some very important notions in physical chemistry. An advanced student has sufficient judgment in regard to these uncertain points, but for a beginner in a science, I prefer sure ground; as little as possible of theory, as much as possible of fact. This uncertainty applies particularly to ions. A great deal has been learned with the notion of ions to guide the chemist, but most of the necessary experiments have been made in water solutions, and perhaps the ionic theory will have to be rejected when the countless other solvents are carefully examined. Indeed, according to the preliminary experiments of Kahlenberg in Wisconsin, the ionic theory is not applicable to all liquids. So I should prefer at the stage of development of physical chemistry, to bring it in at the end of the undergraduate course, when the mind of the student has much matured. In a few years more, perhaps, these questions will all be settled and then an outline of physical chemistry can profitably precede experimental chemistry in the first year. As physical chemistry is so well organized, it can be taught in two ways, the inductive and the deductive. The student being now in his senior year, I should prefer the deductive method; that is, I should prefer to express a particular class of facts in general terms, and then apply to special cases. This way will not do so well for immature minds.

Class room work should abundantly accompany laboratory work. Too much drill in the class room can hardly be given, provided the drill is of the right sort. I do not know whether it is the experience of others, but I have found that students seem to feel that anything involving memory is in a way despicable, and yet without a good memory well stored with facts, a man is heavily handicapped in scientific work. Our most eminent chemists are walking dictionaries of chemistry as well as powerful thinkers.

This finishes the sketch of what it seems to me a chemical course should be for the purposes of education. The majority of college graduates will stop at this point, so that the course for them will be only to show how chemists proceed to study nature, but those who intend to continue are supposed to be ready to pass on to the study of chemical investigation, to help advance towards that all important question as to the destiny of the universe and

the nature of life. In putting such a question, we of course imply the possibility of finding an answer. Some of us may be of the opinion that such a question to nature is idle, altogether idle, that the answer to it can never be compelled; it is only to be obtained by revelation. To those the study of chemistry will not be so far reaching; to them it will only mean a search for knowledge to place themselves in harmony with nature or to gain wealth. Both very meritorious purposes, and I am in sympathy with them, but I would also claim for the study of science the other far more powerful incentive. I would claim that we have already made visible progress towards the answer. The two laws of conservation of energy and of conservation of matter are two discoveries whose importance we are apt to underestimate. On these two facts depend indirectly the recognition of an all pervading substance which we call the ether, a substance which connects us with bodies inconceivably remote. We know that the activity with which we are endowed is indestructible, that the matter of which we are composed is likewise indestructible, and that we are in touch with the remotest parts of the universe. Is it, then, unreasonable to claim that we shall in time find out what development this universe is to undergo, what life is? I think not, and the way in which we shall find out these things, I would claim, will be a chemical way. Put away chemistry from the list of sciences, and we shall hardly find in those remaining means of justifying the laws of conservation of energy and of matter, and a recognition of the ether. We might think that biology, dealing with life, would serve better than chemistry, but before life can be defined, the material which permits life to exist must be understood, and this material the chemist deals with in its various forms. On the other hand, when it would seem that astronomy should tell us about the origin and destiny of the universe, we should not forget that the foundation of astronomy, gravitation, is still wanting an explanation, and that the chemist is the one to give it. Whatever view we may take of the universe, we finally come back to the substances that the chemist deals with, and so we should look to him for an answer to the questions put at the beginning.

This is not a materialistic doctrine. It does not say that we have in matter all that is needed to account for life and to

foretell the destiny of the universe. Not at all. It does claim, however, that nature is a connected whole, and that accordingly no matter where the place may be from which we start, if we proceed systematically, with care and with wisdom, we shall gradually work our way onward, passing into subjects altogether new to us, finally reaching a satisfactory explanation of life and the destiny of the universe. And I claim that the road we shall travel will lead us through the field of chemistry directly into the unknown, and so I would claim for chemistry a first rank in the scheme of education.

THE PLANTING OF CHEMISTRY IN AMERICA.

BY RUFUS PHILLIPS WILLIAMS.

(Concluded from page 82.)

In the fall of 1810, the medical school was transferred to Boston, the first lectures being given in the house of Dr. Warren. But the connection with Cambridge was only partially severed, as it was provided that some lectures should be given at the college. This in later years became the cause of much vexation, for the same chemical apparatus was used to a large extent in lectures in both Cambridge and Boston, and every year it had to be carried over the Charles River from medical school to college, back and forth. This continued till 1858, when a separate professor was appointed for each institution. In the early years this transportation was not so irksome for the number of chemistry lectures given at the college was very small and the science formed but a minute part of the liberal education of a Harvard student during the first half of the 19th century.

In 1846 the medical school was transferred from Mason street, where it had been for more than thirty years, to a new building in North Grove street, and ultimately a chemical laboratory was constructed in the basement and fitted for 138 students. Each student had "his own place and his own apparatus for practical work in analysis and other chemical processes." This plan, so

universally adopted half a century later, was then a great innovation, but even here the laboratory was not used much for several years. Dr. John W. Webster was then professor of chemistry at both the medical school and the college, having been appointed in 1827 to succeed Dr. Gorham, as Erving professor of chemistry and mineralogy in Harvard. The year before his appointment, Webster wrote a voluminous, well illustrated text book of chemistry, which ran through three editions. His term of service of twenty-three years as professor was terminated by his resignation in 1850 and his execution the same year for the murder of Dr. Parkman nine months before. The amount of chemical knowledge obtained in those days may be inferred from the description of one of his lecture courses in the college. He "gave the class two or three chemical lectures, which were brought to a sudden end by his show experiment called *the volcano*—a large heap of sugar and potassium chlorate piled on a slab of soapstone. After he had lighted it with a drop of sulphuric acid, he saved himself by dodging out of the room and in a very few seconds all the members of the class found themselves obliged to jump out of the window." Professor Horsford later gave a voluntary course of three lectures. Such instruction after almost three-fourths of a century of chemistry in the college shows that science was not greatly fostered. In truth "chemical teaching in Harvard College had become extinct." The laboratory method invented by Liebig early in the century and introduced into the universities of Europe, was slow in being put into operation here. It was for Webster's successor, Josiah P. Cooke, to inaugurate this revolutionary change and to place chemistry on a par with classical studies.

When in 1848 Eben Horsford—a student under Liebig—was appointed professor of chemistry at the Lawrence Scientific School, just opened, he brought with him from Giessen the laboratory method of his illustrious master. The new building was at first entirely given up to chemistry and "a laboratory unsurpassed in Europe even at that time, for convenience for practical instruction, was erected and furnished." At practically the same time, Louis Agassiz was called to the chair of geology and zoölogy in the same institution. This was twenty-three years before the scientific school

became a part of the university, but both Agassiz and Horsford introduced a new system of teaching—instruction by the laboratory method—and in both cases the student was mainly thrown on his own resources. This method proved more successful in natural history than in chemistry. Professor Chandler, one of the pupils in 1853, describes the latter as follows: "There were about a dozen students in the laboratory, of whom half were beginners. We were given Will's Qualitative Analysis, and were set at work upon the 'hundred bottles'. After we had finished them, we began to make quantitative analyses, but we soon met a difficulty, which at that time prevailed generally in the United States; it was the lack of any systematic, organized course of study for the chemical profession. We were simply turned into the laboratory. There was no regular graded course of study, consisting of two, three or four years, including not only chemistry, theoretical, analytical and industrial, but other studies necessary to the young chemist. As a matter of fact, there were no lectures on chemistry at all for the students of the scientific school. We were expected to provide ourselves with text books and study them by ourselves at home." The number of students of science was small and all were special students. From its opening down to 1872, when it became a part of the university, degress in chemistry had been conferred on only 55 persons. Professor Horsford resigned in 1862 for the larger emoluments of manufacturing chemistry.

Among the young men who saw the volcano experiment, mentioned above, and made an exit through the nearest window, was one who was to take front rank in America among teachers and investigators in the science. The environment was not promising. But long before entering college he had done more experiments than were laid down in the curriculum. As a boy, Josiah Cooke had read that fascinating work of Mrs. Marcet, called *Conversations on Chemistry*—a book which for nearly half a century kept issuing from the press and stirred more youthful minds in England and America than perhaps any other chemistry ever written. Later, when Professor Silliman of Yale in 1840 gave a course of chemical lectures with experiments, at the Lowell Institute in Boston, Cooke was an earnest listener. At his Boston home he

improvised a laboratory, made and set up his own apparatus and repeated the Lowell Institute experiments with many others culled from Turner's Chemistry. The half dozen lectures during the college course did not profoundly add to knowledge obtained in this manner. And so we learn with some surprise that in 1849, the year after his graduation, he was appointed instructor in chemistry and mineralogy, and in 1850 was appointed to the chair made vacant by the hanging of Webster. He was then 23 years old, had had a teaching experience of little over a year and won the position in competition with David A. Wells, the afterwards distinguished political economist. The college had no apparatus and Cooke furnished what he used from his private laboratory. Then he went for a few months to Europe and bought apparatus and chemicals at his own expense for both medical school and college. The task was difficult. Science teaching was not favored by college faculties or overseers. There was a small lecture room but no laboratory. All that was required was a few lectures. But Cooke started a humble laboratory in a small basement room below his lecture hall and invited a few students to experiment with him. There was no running water nor gas. Charles W. Eliot, afterwards professor of chemistry at the Massachusetts Institute of Technology and now president of Harvard, was the first student admitted to this little first laboratory, and F. H. Storer, since eminent as an agricultural chemist, was another. Seven years later, laboratory work was made a requirement for college students studying chemistry. By 1853, Cooke had equipped the medical school in Boston so as to take a few pupils in qualitative analysis. "It is believed that this was the beginning in the United States of laboratory instruction in chemistry for medical students."

Professor Cooke was an indefatigable worker. His researches in atomic weight, classification of elements, specific gravity, mathematical crystallography, and in other lines, as well as his many publications, gave him an international reputation. His *New Chemistry*, first issued in 1874, was "translated into all the civilized languages of the globe." With all his attainments he was a self-made chemist, having "never worked for an hour in any laboratory but his own." For nearly half a century he was head of

the chemical department of Harvard. He saw it rise from almost nothing to one of the largest departments in the university; from a cellar corner to a large three-story granite building, now completely filled with laboratories and lecture rooms; from recitations of what others had done or might do to elaborate research in every branch of chemistry. "Professor Cooke created the Chemical and Mineralogical Department of Harvard University."

New Jersey.

The first professorship of chemistry at the College of New Jersey—now Princeton—was created October 1, 1795, and Dr. John Maclean was appointed to fill it. He was a young physician and chemist who had studied at Glasgow, London and Paris, and had come to America, locating in Princeton, where he was practicing medicine. Imbued with the theory of Lavoisier, it seems probable that he was its first teacher in this country. Before his appointment he had been invited to give a course of lectures on chemistry in the college. This course made such an impression on the faculty that at the very next meeting he was elected. It has been claimed that, aside from chairs of chemistry in the various medical schools of Philadelphia, New York and Cambridge, this was the first professorship in that science primarily for under-graduates, unless such professorship included natural philosophy or mathematics. The records of William and Mary College dispute this claim. Besides his lectures, Professor Maclean was allowed to continue to practice medicine, until the death of Dr. Minto, in 1797, at which time it was "ordered that chemistry and natural history be taught as branches of natural philosophy," and Maclean devoted his entire time to the college—this step being in accord with the usage of the times.

An account given by one Dr. Alexander of a visit to Princeton in 1801, was that "Dr. Maclean emigrated to America in 1795 and became one of the most popular professors who ever graced the college. He was at home almost equally in all branches of science. Chemistry, natural history, mathematics and natural philosophy successively claimed his attention." He was a native of Glasgow and entered the university in his thirteenth year. While a student there he and some of his companions formed a chemical society,

several of whose members afterwards rose to eminence. A book, *Lectures on Combustion,* which upheld the principles of Lavoisier as opposed to phlogiston, was from his pen, as were several papers in opposition to Priestley's views, published in the *New York Medical Repository.* Professor Silliman said of him: Dr. Maclean was a man of brilliant mind with all the acumen of his native Scotland, and a sparkling of wit gave variety to his conversation." In 1812 he resigned to accept a position elsewhere.

Connecticut.

The teaching of chemistry in Yale was not as an adjunct to medicine. For this reason it did not gain a foothold till the 19th century. In 1798 the president and fellows of Yale voted that a professorship of chemistry and natural history be instituted as soon as there were sufficient funds. It was four years ere the funds materialized. Benjamin Silliman was a graduate of the college, had been a tutor in it, and had finally settled upon the legal profession for a life work. There were scarcely any scientific books, there was no apparatus, and Silliman "had not learned the rudiments of science." But President Dwight's acumen saw in him a scientific diamond, and he finally persuaded him to abandon the law and accept the newly made chair of chemistry and natural history. The young professor in 1803 went to Philadelphia—almost the only place in America where he could study the subject to advantage—attended the lectures of Woodhouse and experimented together with his companion, Hare. On his way to the Quaker City he stopped at Princeton and made the acquaintance of Professor Maclean, of whom he afterwards said: "I regard him as my earliest master of chemistry, and Princeton as my first starting point in that pursuit, although I had not the opportunity to attend any lectures there." Years afterwards, while visiting the laboratory at Princeton, Professor Silliman remarked: "It was in this room that I saw the first experiments in chemistry ever witnessed by me." Next year he began lecturing to the students of Yale College, but, feeling his own deficiency in subjects of which he had set himself up to be master, he went abroad in 1805 and attended lectures mainly in London and Edinburg. After an absence of little over a year, he entered upon that brilliant

career in education and journalism which continued for half a century. Eminently a teacher and popularizer rather than a discoverer, he was "almost the father in this country of the three sciences in which he gave instruction. For many years the study of chemistry was the most popular one in college." The first third of the year was devoted to chemistry, the second to mineralogy, the last to geology. With an unusual assiduity he taught these subjects year after year with scarcely a break—except during one year of sickness—till 1851, when he took a second European trip. From 1835 to 1840 he gave popular lectures in many large cities from Boston to St. Louis and New Orleans. It was at one of these courses—the first lectures ever given at the Lowell Institute, January, 1840—that young Josiah Cooke gained the inspiration to follow science as a profession.

When Silliman entered upon his duties at Yale, there were "only minerals enough to fill a candle box," but he at once set about securing more, and finally after great effort he raised $20,000 and bought the Gibbs cabinet—then the best mineral collection in the United States.

Realizing the need of a periodical which should give the latest discoveries and inventions in science, especially in the three which he taught, he began in 1818 the publication of *Silliman's Journal,* afterwards called the *American Journal of Science.* Pecuniarily it was a losing venture, and for years the struggle for existence was severe, but it had been founded for science, not lucre, and it soon became the leading organ of its kind. In its pages for the major part of the century one can find the tabs of scientific progress. In 1830 he issued a text book of two octavo volumes. Here, in the history of education, the great teacher of chemistry in the college was the first one. For more than fifty years he was a member of the faculty, resigning in 1853, though he continued his lectures two years longer, his son being then appointed in his place.

New Hampshire.

It was more than quarter of a century after Wheelock in 1770 built the "log hut about eighteen feet square, without stone, brick, glass or nails," which formed the beginning of Dartmouth College,

that the first suggestion of a school of medicine was made. Dr. Nathan Smith in 1796 proposed to the trustees to give medical lectures to the students. Next year the lectures were given, and the following year a department of medicine was established by the election of Dr. Smith "Professor of Medicine." He was the veritable autocrat of that school, being clothed with the "power to employ assistants according to his wishes." The northwest corner of the lower floor of Dartmouth Hall was set apart for his use and constituted the medical school. The first course opened November 22, 1798. He selected as the lecturer on chemistry Dr. Lyman Spalding, a graduate of the Harvard school, class of 1797. Spalding evidently had been trained in the doctrine of Lavoisier, for we read that he had printed for his class "A New Nomenclature of Chemistry, proposed by De Morveau, Lavoisier, Berthollet and Fourcroy, with Additions and Improvements." Other lecturers on chemistry who followed Spalding were Rufus Graves, Esq., and Dr. Daniel Oliver, but there was no established chair until 1820. That year there was founded a "professorship of chemistry, mineralogy and the application of science to the arts." Dr. James F. Dana was appointed, who held the place for half a dozen years, and was succeeded in 1827 by Rev. Dr. Benjamin Hale, who—on account of espousing the Episcopal faith with too much ardor for the orthodox college—lost his position in 1835 by the abolition of the professorship, which, however, was restored next year, Dr. Oliver Payson Hubbard being appointed to the place. In Hale's valedictory letter to the trustees on the loss of his chair, one gets a spicy insight into the scientific apathy of the age. In it he says: "It is a remarkable fact that there is not one member of your board whose pursuits in life lead him to any acquaintance with physical studies, and I presume the importance absolute and relative of such studies is viewed by you as it stood in American colleges from thirty to fifty years ago when you were undergraduates. And your college feels the effect of this deficiency. It has not taken a scientific periodical, so far as I know, for half a century. The few that have crept into your library you owe to the charity of a pamphlet society which, through the influence of the late Professor Dana, among its other periodicals took one *Quarterly*.

Journal of Science, and at its decease bequeathed its collection to your library. Since its death, no report of the progress of science finds its way within your walls, save the *Journal* of Professor Silliman, taken by the two respectable societies among the students * * *" "A few years ago, no provision was made for chemical lectures to college classes, and members of the higher classes were in the habit of making a contract annually with my predecessor, Professor Dana, for the privilege of attending his lectures." Before Hale's advent, seniors were allowed to attend lectures on chemistry and anatomy on payment of $4 per year, juniors $2. Afterward seniors and juniors were allowed to attend the fourteen or fifteen weeks of daily lectures which Hale delivered to the "medics". Hale also had five or six weeks of daily recitation with the junior class, and gave to the undergraduate college students a separate course of thirty lectures per year. He established a course of twenty lectures in geology and mineralogy, and collected a cabinet of some 2,300 minerals where there were none before.

Dr. Hubbard, the successor of Hale, had one of the longest careers in the profession, his term as professor of chemistry in the Dartmouth Medical School lasting for forty-seven years, ending in 1883. Meantime, science in the college had been divorced from that in the medical school, each having its own chemical teacher.

Thus were planted in seven early institutions of learning in this country the seeds of that science which in little over a century has grown to enormous proportions. In tracing its origin and growth in these American centers, more space has been given to some because of the greater personality of the early educators and the more ample records available. Among all these men, three—Hare, Silliman and Cooke—pre-eminently distinguished themselves and gained a world-wide reputation.

Our research has shown that the first medical school in America was opened in 1765 in Philadelphia; that the first professorship of chemistry was established in 1767 in New York, with Samuel Smith as first professor; that the first professor of chemistry outside of a medical school was James Madison, of William

and Mary, in 1774; that the first teaching of anti-phlogiston (i. e. of Lavoisier's chemistry) was probably in 1795, at Princeton by Dr. John Maclean; that Dr. James Woodhouse of Philadelphia was the last man, 1809, to inculcate the phlogiston doctrine; that laboratory instruction was introduced in 1848 by Eben Horsford at the Lawrence Scientific School; that the earliest laboratory instruction in medical schools was given in 1853 by Professor J. P. Cooke, at the Harvard Medical School.

SHALL THE PREPARATION OF A HERBARIUM AND THE IDENTIFICATION OT SPECIES FORM A PART OF THE REQUIRED WORK IN BOTANY IN OUR SECONDARY SCHOOLS?

BY GILBERT H. TRAFTON.
Normal School, Randolph Center, Vt.

(*Concluded from page 94.*)

This very hurried survey of what the new botany offers is too fragmentary and brief to be called even an outline, and certainly does not do justice to the course as it may be carried out. But it may suggest, perhaps, the line along which the work proceeds. It hardly seems necessary to add that the very essence of ecology is the field work. No matter how commonplace the lesson to be taught or the object to be studied, it means far more to the student to see a plant growing in its natural surroundings than to see it only in the school room.

I now come to the last head under which I propose to speak of my subject, the stand of authorities on this question. In this time of individual religious freedom and rejection of any external, final authority, I would not seem to place botany on a less rational basis relying too much on the men who write our text books and conference reports. But as the majority of us who are teachers give instruction during the year in from five to fifteen subjects, and so are not able to deal exclusively with those subjects in which we are especially interested, it would seem fitting that we should

consider most carefully the suggestions of those who make a life work of teaching botany alone.

During the last three or four years, being especially interested in botany, I have taken opportunity to examine the better known botanical publications that have appeared since 1893, including text books, reports of committees and articles giving outlines for botany courses. At this time I will give you the results of a comparison of sixteen such publications, representing the opinions of about seventy-five botanists, including a large number of the best known botany teachers in our country. These publications include text books by Atkinson, Bailey, Barnes, Bergen, Bessey, Coulter, Ganong, Macbride, Pepoon, Spalding and Setchell, an outline by Lloyd, and the reports of four committees, that of the New York State Science Teachers' Association, of the Committee of Ten, of the Committee on College Entrance Requirements, and of the Committee appointed by the Society for Plant Morphology and Physiology.

At this point I will call your attention to the fact that I am balancing these authorities, not on the place to be assigned to special morphology in the half-year course, but on the question of the use of keys and the preparation of herbaria. For there are some who would retain the study of special morphology, though not by the methods just mentioned, but by a systematic study of families. But those who favor the retention of special morphology by any method form a very small minority. On the phase of the question that we have under discussion, however, the weight of authority is overwhelmingly in the negative, condemning the identification of species and the preparation of herbaria as a part of the required work in a half-year course, either directly when the matter is referred to or indirectly by excluding such work from the course outlined. Only two sanction the use of keys, Bailey and Bergen, and only one encourages the preparation of a herbarium, Bailey; but even then not in the aimless and indiscriminate way in which it is usually done, but with something definite in view to be illustrated by the collection. He says: "Too often the pupil thinks it sufficient merely to have made a collection, but the collection of itself is scarcely worth the while."

In thus showing the almost unanimous opinion of these authorities on this matter, perhaps it would seem that nothing more need be said, but I do wish, however, to call your attention to a few things in this connection. I have referred to Bergen as giving sanction to the use of keys, but yet he can hardly be said to encourage this work. Lest the fact that a key and flora has appeared in his new book should make his position misunderstood, I will quote from his "Foundations and Handbook." He says: "The author does not believe in spending much of the time of a class in identifying species. To him the analysis of flowering plants seems one of the least important of the many topics for study by a class in elementary botany." And again in his suggestions for a half-year course, he says: "Determine a very few species by aid of the Key and Flora, merely to illustrate the method." I have taken time to quote Bergen because his books are used quite extensively in New England and because the enlarged Key and Flora in his new book might seem to imply that he would assign an important place to the use of the Key, while he really lays but little stress upon it, as shown by the quotations which I have just read. But it should be borne in mind that Bergen's position in allowing a place for the key in a half-year course, even though it be but a very subordinate place, is not the position of the great majority of the authorities cited, who would allow no time whatever for such work.

My purpose in referring again to some of the other publications already mentioned is to emphasize the careful consideration which is their due, owing to the great weight of authority represented. I wish to call your attention in particular to the report of the committee appointed by the Society for Plant Morphology and Physiology. This committee, consisting of Ganong, Lloyd and Atkinson, was appointed at the meeting of the Society in December, 1900, to formulate a standard college-entrance option. A provisional report was made in the following April and a copy sent to each member of the Society with the understanding that it must receive the approval of a majority of the members before being completed, and that any suggestions made by a majority of them must be incorporated in the final report. This final report has been prepared and is the document to which I refer above. So this pub-

lication represents not merely the opinion of the three men on the committee but of a large majority of the members of the Society, for in this report is found the following: "The opinions called forth by the provisional report have displayed an almost unanimous approval of its main features, while the criticisms have been surprisingly few." The membership of this Society numbers about fifty-five and includes men who need no introduction to this Botanical Club, such as Professors Burt, Jones and Robinson, and other well known botanists of our country, as Atkinson, Bailey, Coulter, Farlow, Ganong, Goodale, Lloyd, MacDougall and Spalding. This report seems to me to be one of the most important documents to botany teachers published in the last decade.*

Lest the fact that the course here outlined is recommended for a college-entrance option would seem to make its bearing on our case less direct, I will suggest that as far as I know, our educators are practically unanimous in the opinion that there should be no difference in the treatment of the various subjects in our high-school curriculum for those going to college or scientific school, and those going to neither.

I wish to read that part of the report which refers to the methods of teaching botany that we are discussing. It reads as follows: "The ability to use Manuals for the determination of the species of flowering plants is not considered essential in this course, though it is desirable. It should not be introduced to the exclusion of any other work, but may well be made voluntary work for those showing a taste for it. It should not be limited to learning names of plants, but should be made a study in the plan of classification as well. The preparation of a herbarium is not required nor recommended except as voluntary work for those with a taste for collecting. If made, it should not constitute a simple accumulation of species, but should represent some distinct idea of

*This report in its official form is printed elsewhere in this number of SCHOOL SCIENCE (Pages 159-165), the first appearance of the third edition. Its publication here will be the more welcome to our readers, inasmuch as the recent formal adoption of the course it recommends by the College Entrance Examination Board makes it the official entrance option for all the leading universities and colleges of the Middle States and Maryland accepting Botany for entrance, and for many of those of the neighboring states. The example of these institutions, together with the very wide approval it has received from prominent teachers, is likely to lead to its general adoption in this country as a standard course for high schools and for entrance to college.—EDITOR.

plant associations, of morphology, of representation of the Groups, etc."

Thus the position of the report in not recommending either the use of keys or the preparation of herbaria as required work is clear. But there is still one other very important point to be noted. Even when this work is done voluntarily, this report would place it at the end of the full year course and not in connection with the half year course. As far as our Vermont problem is concerned, then, where we give but a half year or less to botany, this report leaves no place whatever for the key and the herbarium, even as voluntary work.

The three points which I have tried to emphasize with reference to the key and the herbarium as required work in our short courses are, first, that they are not justified by the results which they yield, second, that the new botany has something to offer in their place which is far superior, and third, that those authorities who have expressed themselves on the matter either directly or indirectly, are almost unanimously opposed to these methods.

As helpful text books which embody the modern spirit I would suggest Bergen's "Foundations of Botany," without the Key and Flora, Atkinson's "Lessons in Botany," and Coulter's "Plants," more especially the first for gross morphology, the second for physiology, and the third for ecology. For a clear and detailed treatment of the whole subject of botany teaching, I recommend most heartily and without reserve Ganong's "Teaching Botanist." No teacher of botany can afford to be without a copy.

And, lastly, of those here who are not teachers I would beg that they foster the better spirit of botany teaching, at least in the negative way, by not implying that a student's knowledge of botany is to be measured by his ability to name the common plants.

THE DUTY OF THE UNIVERSITY TO THE SECONDARY SCHOOL TEACHER OF PHYSIOLOGY AND HYGIENE.

BY W. H. MANWARING.

Johns Hopkins Medical School.
Formerly Professor of Physiology and Hygiene, State Normal School, Winona, Minn.

Thirty years ago, the teaching of physics and chemistry in our high schools and academies was almost exclusively by the text-book method. During the last quarter-century, there has been introduced in these sciences class-room demonstrations by the teacher, and, later, laboratory exercises by the pupil. There has resulted a universal knowledge of the value of such demonstration and laboratory work, so that, today, no sane teacher would attempt either subject without using both.

The introduction of scientific methods in the teaching of high-school botany and zoölogy is of more recent date. Even today, real laboratory methods are not used in more than a bare majority of schools. There is, however, a widespread belief that either subject, without laboratory instruction, is sterile and worthless. Our universities are each year turning out graduates better prepared to direct such work and more thoroughly convinced of its value, and we may look, in the near future, for its wider use.

While the teaching of physics, chemistry and zoölogy has been so greatly improved, the teaching of physiology and hygiene is almost where it was a half-century ago. It is safe to say that in 95 per cent of the high schools the teaching is by the old text-book method exclusively, that in but few is real demonstration work attempted, and that in not more than a score is laboratory work required. Still physiology and hygiene, even more than chemistry, is barren and worthless without this practical work.

For a number of years, the leaders in educational movements have recognized the uselessness of mere text-book instruction in thus subject, and have endeavored to secure a wider adoption of laboratory methods. Their efforts, however, have been attended with scant success.

The reason for this is the difficulty they have had in obtaining teachers prepared to use the newer method. Teachers now in service are, with rare exceptions, lacking in the practical training necessary for this work, and, under the present arrangement of university studies, they have no opportunity of obtaining such training without undue sacrifice of time and money. For the salaries paid in the majority of schools, it seems impossible to obtain recent graduates who have had a laboratory training in the large number of subjects that specialization in university work renders necessary for this work.

Under the existing system of university teaching, if a graduate has not had a laboratory training in anatomy, histology, embryology, bacteriology, pathology, and physiological chemistry, in addition to his preparation in pure physiology, physics, chemistry, and general biology, he is not prepared to undertake with success modern instruction in elementary physiology and hygiene. A university training in pure physiology is not sufficient. First, because the work in the secondary school is not work in pure physiology at all, but is properly a combination of the rudiments of all of the preliminary medical sciences. Second, because the department of physiology in our universities is usually in the hands of a specialist in some one particular subdivision of pure physiology, who is generally not interested in secondary schools, who is always out of touch with them and their methods, and who is usually even out of sympathy with them and their aims.

Teachers, however, could be prepared for this work in a very short time, if our universities would offer a well systematized TEACHERS' COURSE IN ELEMENTARY ANATOMY, PHYSIOLOGY, AND HYGIENE. Such a course should consist of laboratory instruction in those elements of the various subjects mentioned above that it is necessary the secondary teacher should know, together with lectures on the pedagogical and scientific sides of the subject. The course should be systematic and thorough. Above all, it must be given by a man in direct touch with secondary schools and of broad understanding of their aims and needs.

Such a course should be planned to meet the needs of two classes of students; first, university seniors who are preparing to teach in secondary schools; second, and most important, high-

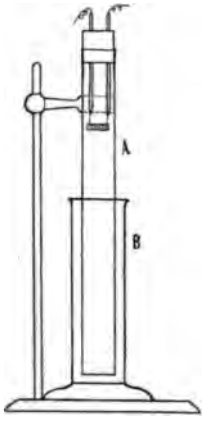
school teachers now in service who have not had a training in laboratory methods. It should be given during the summer months so that both could profit by it. Should such a course be offered by any one of our prominent summer schools, as that of the University of Chicago, or of Harvard University, it would be largely attended.

There is great need for work along this line. The wide-awake school men know this and the superintendents are anxious for it. It only remains to be seen how long it will take the universities to realize this fact and act accordingly.

A METHOD OF DETERMINING THE RELATIVE AMOUNTS OF OXYGEN AND NITROGEN IN THE ATMOSPHERE.

BY GEORGE C. ASHMAN,
Department of Chemistry, Bradley Polytechnic Institute, Peoria, Ill.

Mr. Sparling, a student in this laboratory, and myself have devised the following method for determining the relative amounts of oxygen and nitrogen in the atmosphere. *A* is a tube of hard glass, 30 cm. in length and 25 mm. in diameter, open at both ends.



The upper end of the tube is closed by a tightly-fitting, two-hole rubber stopper which carries two small glass tubes with heavy platinum wires sealed into their lower ends. These wires support a coil of about ten turns of small platinum wire. This coil carries a piece of charcoal of convenient size.

After the stopper with the tubes, the coil and the charcoal has been placed in position, the upper portion of the tube *A* is graduated into six equal divisions of about 20 cc. each.

B is a cylinder partly filled with mercury. By removing the stopper five divisions of the tube *A* can be filled with air and se-

curely closed at the atmospheric pressure by again tightly fixing the stopper.

The small glass tubes are partly filled with mercury, and by this means electrical contact is made.

The current is turned on slowly at first, but the coil is finally brought to bright redness. If 100 cc. of air are used the coil should be maintained at a bright red heat for thirty minutes. During the burning and subsequent cooling the pressure is maintained constant by adjusting the inner tube.

When the current is turned off and the gas has recovered the temperature of the room, it is found to occupy six divisions of the tube *A*.

The oxygen has united with the carbon to form carbon monoxide, and as one volume of oxygen yields two volumes of carbon monoxide, it is obvious that the oxygen originally contained in the air occupied a volume equal to one of the divisions of the tube.

The experiment is a very satisfactory one for lecture demonstration, especially if the students have previously studied the oxides of carbon.

The charcoal used must first be heated to redness in a stream of chlorine to free it of all absorbed gases.

AN EXPERIMENT SHOWING THE RELATIONSHIP BETWEEN PRESSURE AND BOILING POINT.

BY C. E. LINEBARGER.

The apparatus (Fig. 1) consists of a flask (best round bottomed, as flat bottomed ones sometimes burst when exhausted of air) of from 200 to 500 cc. capacity, fitted with a rubber stopper through which passes a glass tube bent twice at right angles. The longer branch (80cms.) dips in a vessel containing some mercury. The flask is supported by means of a ring with wire gauze and clamp on a retort stand.

The flask is filled about a third full of water to which a pinch of some fine, insoluble powder, as powdered marble or precipitated

silica, is added. Some hydrant waters, when boiled, have a sediment separate out which answers very well. Water which is entirely free from finely divided particles does not boil easily and regularly, and does not illustrate the point in question as well as a water holding solid matter in suspension.

The water is heated to boiling and as soon as the escaping

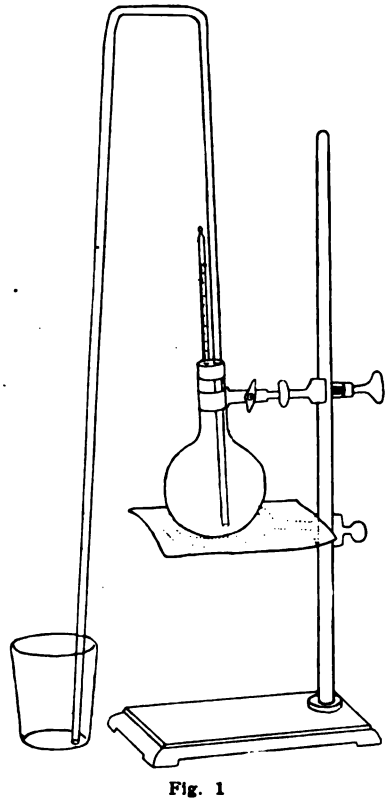


Fig. 1

steam causes crackling reports as it passes into the mercury (evidence of the complete expulsion of the air), the flame is removed.

Usually as the flask cools off, the boiling continues and the mercury rises with an oscillating motion. If, however, the solid nuclei are not of the right nature, the boiling ceases and the mer-

cury rises steadily. That vapor is given off in both cases may be seen from its condensing in the tube and either running back into the flask or collecting over the mercury in the longer branch.

If a stream of water (from a wash bottle) be played over the flask, the water in it boils vigorously and the mercury oscillates, falling when a bubble of steam is formed, but rising again at once; and it is to be noted particularly that the mercury is always finally at a higher level after the drenching with water than before.

The above is but a modification of the so-called Franklin's experiment which is described in nearly every text book of physics.

The reason that boiling ensues when the outside of the flask is cooled is that the aqueous vapor in the flask is partially condensed and the formation of additional vapor thereby rendered possible, with a boiling effect. The form of apparatus just described shows directly that the higher the temperature, the greater the aqueous tension, but it is perhaps not superfluous to caution the teacher to be sure to make clear to the student that the relationship between aqueous tension and temperature is not a simple one and that it is different for every liquid, for otherwise the student may think that a sort of Charles' law can be here applied.

This apparatus may also be made to give quantitative results, by using a two-hole stopper and a thermometer whose bulb dips below the surface of the water in the flask. A series of readings of the temperatures and the corresponding lengths (measured with a meter stick) of the mercury columns are made and the pressures found by subtracting these lengths from the barometric reading. The results obtained are not very accurate, but when plotted, give a curve which brings out very well the facts in regard to the dependence of vapor tension on temperature.

To emphasize the fact that an increase of pressure raises the boiling point, more mercury may be poured into the cylinder so that the steam has to overcome the added pressure of the mercury in order to escape. The water should be made to boil vigorously and the temperature read from the thermometer after each addition of a small portion of mercury (enough to raise the level of the liquid metal 2 or 3 cm.). The stopper should be wired in, and it is perhaps not safe to raise the boiling point above 105°.

THIRD REPORT
of a Committee Appointed by
THE SOCIETY FOR PLANT MORPHOLOGY AND PHYSIOLOGY,
AT BALTIMORE, DECEMBER 28, 1900,
to Consider the Formulation of
A STANDARD COLLEGE ENTRANCE OPTION IN BOTANY.

The present report is based upon the Revised Report issued in September, 1901. It contains some alterations suggested by the communications received by the Committee in response to a request for comments and criticisms upon the earlier editions, but the changes are few and unimportant. They consist chiefly in the addition of Principle 5 and some verbal changes intended to call attention more prominently to the possibility of making the study of the Groups (of Part II.) the principal part of the course, the topics of Part I. being incorporated at appropriate places therein. This has always been admitted as a possibility by the option, but it is only fair to say that it seems to the Committee a less advantageous arrangement than that here recommended, and one from which, and not towards which, educational opinion is trending.

The full year option here recommended was formally adopted by the College Entrance Examination Board (formerly of the Middle States and Maryland) in December, 1901, and appears in their Document No. 8, issued January 10, 1902. Examinations will be held in it for the first time in June, 1902.

The Society for Plant Morphology and Physiology, at its meeting in New York on January 1, 1902, voted to place the option in the hands of a permanent committee, which should be charged to make it as useful, educationally, as possible, and to keep it in touch with changing educational conditions. The former Committee was continued as the permanent Committee.

The Committee:
W. F. GANONG, Smith College, Northampton, Mass.
F. E. LLOYD, Teachers' College, Columbia University, New York.
April 15, 1902.

OUTLINE OF THE PROPOSED OPTION.

(It may be known briefly as The Standard Option.)

PRINCIPLES UPON WHICH THE COURSE IS FORMULATED.

1. It is founded upon the two important Reports of the National Educational Association,—the "Report of the Committee of Ten" (Washington, 1893), and the Report on College Entrance Requirements (Chicago, 1899).
2. It is intended primarily as an option for entrance to College, but equally for the education in the high school of the general student who can follow the subject no farther; there are in Botany no advantages in having the college preparatory and the general educational courses different, at least none that are at all commensurate with the additional burden thus laid upon the schools.
3. It should, if possible, be founded upon a considerable body of botanical fact learned through "Nature Study" in the lower schools; it should form part of a four years' high school course in the Sciences; it should be considered and treated as an elementary or preliminary course leading to second courses in College, and Colleges accepting the option should make provision to articulate second courses economically with it.
4. The immediate plan of its construction is very simple, namely, to include those topics in the leading divisions of the subject which most teachers now regard as fundamental, either for their value in scientific training, or as knowledge; but the individual teacher is left free to follow his own judgment as to sequence of topics, text and other books, and special methods. Advice is occasionally offered, however, upon important points in which most teachers are now known to agree.
5. It recognizes the existence of, and provides for, two modes of procedure in the sequence of topics. In one, that here advised, the general principles of plant structure and function, permitting a beginning with large and familiar objects and phenomena, are first studied, to be followed later by a study of representatives of the Groups of Plants from the lower to the higher; the other makes the study of the Groups the backbone, as it were, of the course, beginning with the lowest forms and introducing the physiological and morphological topics at appropriate places in the ascending series. The two modes, however, lead to substantially the same result, and a common examination is practicable for both.
6. It is designed to yield a mental discipline fully equal in quality and quantity to that yielded by any other subject studied for the same length of time.

7. The time per week, inclusive of recitation, preparation, and laboratory should be the same as for any other subject. Where five periods a week with an hour of preparation for each are demanded for other studies, this course should receive the equivalent of two recitation periods with their preparation, together with three double (not six separated) periods in the laboratory and a small amount of outside related work or preparation. Variation from this should be towards a greater, not a lesser proportion of laboratory work. The preparation of records of the laboratory work, in which stress is laid upon diagrammatically accurate drawing and precise and expressive description, is regarded as an integral part of the course; and these records, preferably in a note-book, must be presented with the examination-paper, and will count one-third towards admission.

8. There must be provided,—
   (*a*) A full year option.
   (*b*) A half year option.
   (*c*) The possibility of a two-years' option.

SPECIFICATIONS.

The *full year option,* to count as 1 unit or point out of 13 to 15 for entrance, will consist of:—

(I.) A half year devoted to the General Principles of Anatomy, Morphology, Physiology and Ecology.

(II.) A half year devoted to the Natural History of the Plant Groups, with Classification.

The full year option may consist, also, of II. enlarged to occupy a year and including the essentials of I. (See Principle 5 above.)

The *half year option,* to count as 1 unit or point out of 26 to 30 for entrance, may consist of either I or II above, but not of a composite of both.

A half-year option consisting of a composite of I and II, although recognized as profitable under some local conditions, is not here included; since, while it is not considered educationally superior, if equal, to I or II more thoroughly studied, it will be impossible for colleges to make arrangements to articulate it profitably with their higher courses in addition to I and II; and, moreover, Examination Boards will find obvious difficulties in providing examinations for it.

The *two years option* will consist of I enlarged to a year, together with II enlarged to a year.

I. The half year option in the General Principles of Anatomy, Morphology, Physiology and Ecology.

The fundamental topics are the following:—

A. In Anatomy and Morphology.

The Seed. Four types (dicotyledon without and with endosperm, a monocotyledon and a gymnosperm); structure and homologous parts.

Food supply; experimental determination of its nature and value. Phenomena of germination and growth of embryo into a seedling (including bursting from the seed, assumption of position and unfolding of parts).

The Shoot. Gross anatomy of a typical shoot; including the relationships of position of leaf, stem (and root), the arrangement of leaves and buds on the stem, and deviations (through light adjustment, etc.) from symmetry.

Buds, and the mode of origin of new leaf and stem; winter buds in particular.

Specialized and metamorphosed shoots (stems and leaves). General structure and distribution of the leading tissues of the shoot; annual growth; shedding of bark and leaves.

The Root. Gross anatomy of a typical root; position and origin of secondary roots; hair-zone, cap and growing-point. Specialized and metamorphosed roots. General structure and distribution of the leading tissues of the root.

The Flower. Structure of a typical flower, especially of ovule and pollen; functions of the parts. Comparative morphological study of six or more different marked types, with the construction of transverse and longitudinal diagrams.

The Fruit. Structure of a typical fruit, especially with reference to changes from the flower, and from ovule to seed. Comparative morphological study of six or more marked types, with diagrams.

This comparative morphological study of flowers and fruits may advantageously be postponed to the end of II, and then taken up in connection with Classification of the Angiosperms.

The Cell. Cytoplasm, Nucleus, Sap-cavity, Wall. Adaptive modifications of walls, formation of tissues.

As to the study of the cell, it is by no means to be postponed for consideration by itself after the other topics, as its position in the above outline may seem to imply, but it is to be brought in earlier along with the study of the Shoot or Root, and continued from topic to topic. Although enough study of the individual cell is to be made to give an idea of its structure (a study which may very advantageously be associated with the physiological topics first mentioned under B), the principal microscopical work should consist in the recognition and study of the distribution of the leading tissues.

B. In Physiology.

Role of water in the plant; *absorption (osmosis), path of transfer, transpiration, turgidity and its mechanical value, plasmolysis.*

Photosynthesis; *Dependence of starch formation upon chlorophyll, light and carbon dioxide; evolution of oxygen,* observation of starch grains.

Respiration; *necessity for oxygen in growth, evolution of carbon dioxide.*

Digestion; *Digestion of starch with diastase,* and its role in translocation of foods.

Irritability; *Geotropism, heliotropism* and *hydrotropism;* nature of stimulus and response.

Growth; *localization in higher plants; amount in germinating seeds and stems; relationships to temperature.*

Fertilization; sexual and vegetative reproduction.

Although for convenience of reference, the physiological topics are here grouped together, they should by no means be studied by themselves and apart from anatomy and morphology. On the contrary, they should be taken up along with the study of the structures in which the processes occur, and which they help to explain; thus,—photosynthesis should be studied with the leaf, as should also transpiration, while digestion may best come with germination, osmotic absorption with the root, and so on. The student should either try, or at least aid in trying, experiments to demonstrate the fundamental processes indicated above in italics.

C. In Ecology.

Modifications (metamorphoses) of parts for special functions.
Dissemination.
Cross-pollination.
Light relations of green tissues; leaf mosaics.
Plant Societies; Mesophytes, Hydrophytes, Halophytes, Xerophytes; Climbers, Epiphytes, Parasites (and Saprophytes), Insectivora.
Plant Associations, and zonal distribution.

The topics in Ecology, (particularly the first four and in part the fifth) like those in Physiology, are to be studied not by themselves, but along with the structures with which they are most closely connected, as cross-pollination with the flower, dissemination with the seed, etc. The fifth and sixth may most advantageously be studied with G in Part II.

In this connection field-work is of great importance, and for some topics, such as the sixth, is indispensable, though much may be done also with potted plants in greenhouses, photographs, and museum specimens. It is strongly recommended that some systematic field-work be considered as an integral part of the course, coördinate in definiteness and value as far as it goes with the laboratory work. The temptations to haziness and guessing in Ecology must be combated.

II. The half year option in the Natural History of the Plant Groups and Classification.

A comprehensive summary of the great natural groups of plants, based upon the thorough study of the structure, reproduction and adaptations to habitat of one or two types from each group, supplemented and extended by more rapid study of other forms in those groups. Where living material is wanting for the latter, preserved material and even good pictures may be used, and a standard text-book should be thoroughly read. The general homologies from group to group should be understood.

In general, in this part of the course, it is recommended that much less attention be given to the lower and inconspicuous groups, and progressively more to the higher and conspicuous forms.

Following is a list of recommended types from which, or their equivalents, selection may be made:

A. ALGAE. Pleurococcus, Sphaerella, Spirogyra, Vaucheria, Fucus, Nemalion (or Batrachospermum or Polysiphonia or Coleochaete).

B. FUNGI. Bacteria, Rhizopus, Yeast, Puccinia (or any Powdery Mildew), Mushroom.

Bacteria and Yeast have obvious disadvantages in such a course, but their great economic prominence may justify their introduction.

C. LICHENS. Physcia (or Parmelia).

D. BRYOPHYTES. In Hepaticae, Radula (or Porella or Marchantia). In Musci, Mnium (or Funaria or Polytrichum).

E. PTERIDOPHYTES. In Filicineae, Aspidium or equivalent, including, of course, the prothallus.
In Equisetineae, Equisetum.
In Lycopodineae, Lycopodium and Selaginella (or Isoetes).

F. GYMNOSPERMS. Pinus or equivalent.

G. ANGIOSPERMS. A monocotyledon and a dicotyledon, to be studied with reference to the homologies of their parts with those in the above groups; together with representative plants of the leading subdivisions and principal families of Angiosperms.

Classification should include a study of the primary subdivisions of the above groups, based on the comparison of the types with other (preferably) living or preserved material. The principal subdivisions of the Angiosperms, grouped on the Engler and Prantl System, should be understood.

The ability to use Manuals for the determination of the species of flowering plants is not considered essential in this course, though it is desirable. It should not be introduced to the exclusion of any other work, but may well be made voluntary work for those showing a taste for it. It should not be limited to learning names of plants, but should be made a study in the plan of classification as well.

The preparation of an herbarium is not required nor recommended except as voluntary work for those with a taste for collecting. If made, it should not constitute a simple accumulation of species, but should represent some distinct idea of plant associations, or of morphology, or of representation of the Groups, etc.

PLANS FOR A BIOLOGICAL LABORATORY.

BY S. O. MAST,
Professor of Biology, Hope College, Holland, Mich.

The plans here presented were drafted for a biological laboratory in process of construction at Hope College, Holland, Mich.

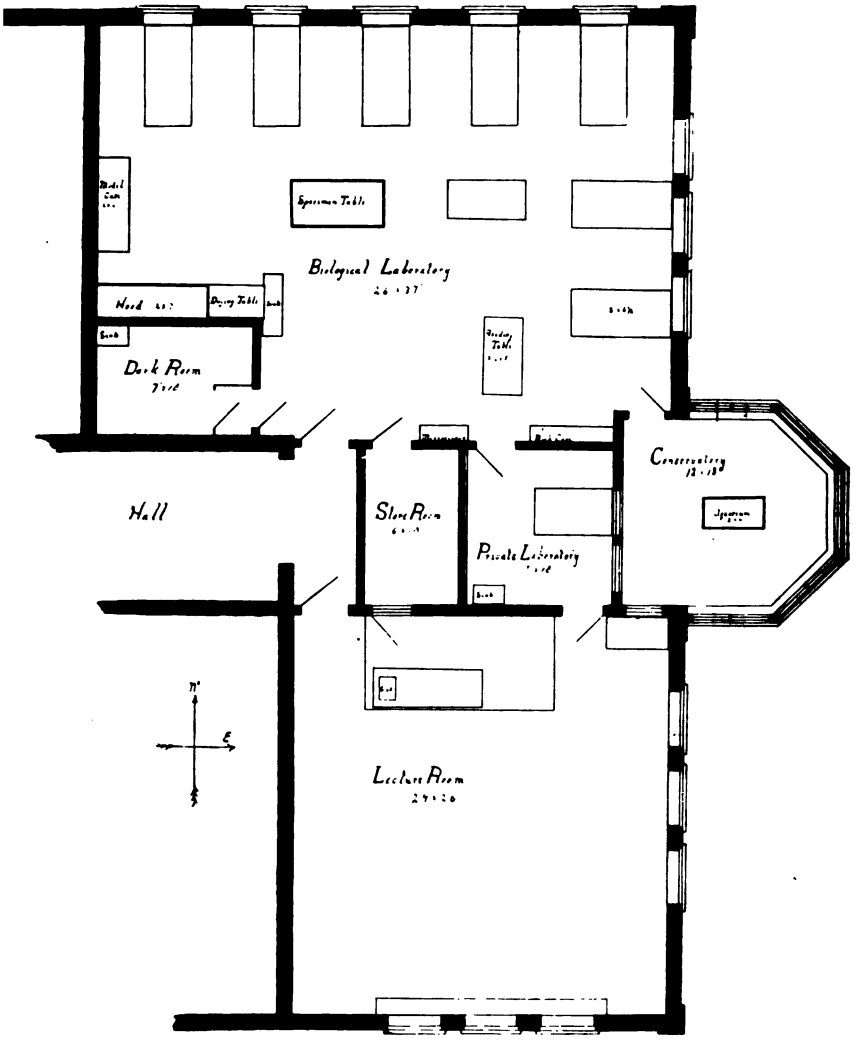
The laboratory will occupy the entire east end of the second floor, and in order to avoid direct sunlight as much as possible, will face the north. It is to accommodate twenty-eight students, four at each of the seven working tables. These tables will be supplied with four drawers on either side. The drawers will be arranged one above the other in the middle of the tables. Adjustable swivel chairs with backs will be used at the tables.

There is a conservatory for plants, with glass roof and sides, and a cement floor connected with the sewer system by a drain. The dark room is to be used both for performing physiological experiments in the absence of light and for work in photography. The store room will accommodate not only biological material, but also chemical glassware, stains, etc. A hood which will accommodate three students at one time is supplied with water and gas.

The lecture room will seat forty. It is adapted for demonstrations as well as quizzes and lectures, being in close connection with the store room, the private and the general laboratories.

We have planned a private laboratory, 9x12 feet—rather small, but better than none. As it is lighted only through the conservatory, it is supplied with both gas and electricity. Every instructor should do some special work. This does not necessarily mean that every instructor should be an original investigator; he should be a teacher first of all. The special work he does may be the preparation of material in new ways for student use, or the working over of old experiments. Such a room, where the instructor may work undisturbed by the thoughtlessness of students, will also give them a wholesome notion of the difference between private and public laboratory belongings.

*Presented before the joint session of the Biological section of the Michigan School Masters' Club and the Michigan Academy of Sciences at Ann Arbor, Mich. (See report of this meeting, page 188.)

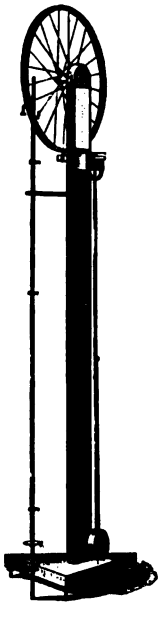

Specimen Table
Biological Laboratory
Desk
Dying Table
Sink
Dark Room
Hall
Store Room
Private Laboratory
Conservatory
Specimen
N
E
Lecture Room

A FALLING BODY MACHINE.

BY A. L. EWING.

Dept. of Natural Science, Normal School, River Falls, Wis.

It has been my privilege this year to place in the hands of students in physics a piece of apparatus by means of which they could determine the laws of falling bodies with only a small percentage of error.



The pupils operated the machine themselves, individually, following brief printed directions. The topic was not discussed previous to laboratory work, and so far as I know the pupils had no idea of the laws they were in search of until they had discovered them.

The machine, invented and patented by J. S. Heminway of River Falls, Wis., consists of a light, nicely balanced wheel, journaled on ball bearings. The falling weight turns this wheel by an unwinding string. The wheel can be accurately set and the elevation of the weight indicated by a marker on a brass rod. The operator now starts a heavy, seconds' pendulum which releases the wheel and permits the weight to fall. There is a light index that moves with the wheel. The same pendulum that released the weight, by an ingenious device, causes this index to stop suddenly at the end of any interval, 1st, 2d or 3d, according to the way the machine was set. By now stopping the wheel and turning it back, so that the zero of the wheel is at the point of the index, the operator can place another marker to indicate the point to which the weight fell. When he has thus found the positions reached at the end of the 1st, 2d and 3d second, he removes the rod to a table where the intervals may be accurately measured.

The pupils were directed to find the ratio, to the nearest integer, between the distance the weight traversed during the first interval and the two intervals, then during the first and

the three intervals, and report percentage of error. They all derived the first, fourth and ninth with errors, falling short, approximately 2 per cent.

For velocity, a table attached to the rod is so adjusted as to stop the weight at the end of the desired second. The string unwound during the next second indicates the velocity at end of the given second. Errors here were similar to those above.

The machine is of convenient size to be operated by one standing on the floor, is adapted to the handling of inexperienced students, and is readily comprehended. The piece of apparatus is not expensive, so that laboratories may be supplied with duplicates.

This piece of apparatus was exhibited at the meeting of the Wisconsin State Teachers' Association, held at Milwaukee last winter. The numerous comments on it were universally favorable.

ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY.

BY GEORGE W. MYERS.

(*Continued from page 110.*)

EXPERIMENT XXXIV.

To find the distance from the earth to the sun.

(a) *By Aristotle's method.*

Note the length of the interval of time from new moon to first quarter as indicated by the straightness of the terminator. Knowing then the length of the lunation, 29.53 days (synodic month, time from new moon to new moon again), and that the moon moves through 360° during this lunation, the angular velocity of the moon, and hence the angle $S\,E\,M$, is obtained. The angle at M being right (90°) at this instant, a small right triangle

may be constructed on paper having any convenient length for $M\,E$ (which represents the distance to the moon found in the last experiment), and the known values for $S\,M\,E$ and $M\,E\,S$, from which the length of the hypothenuse may be read to the scale on which $M\,E$ represents the lunar distance. The hypothenuse so expressed will represent the distance to the sun.

Using times of new moon and first quarter from a common

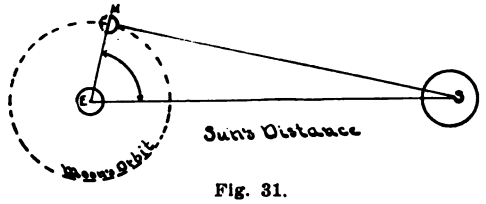


Fig. 31.

patent medicine almanac, and 238,000 miles for the lunar distance, find the sun's distance. Solve the problem both geometrically and trigonometrically if you can.

(b) *Geometrical methods by transits of Venus* will be given after the method of finding relative planetary distances is developed.

Experiment XXXV.

To find distances from sun to Mercury and Venus in terms of earth's distance from the sun.

The earth, E, and Venus (the method will be seen to apply to Mercury also), V, revolve round the sun, S, in the same directions, the earth moving more slowly. When Venus comes into line with the earth and sun, as at $V1$, we say the planet is in *inferior conjunction*, and when it is at $V3$ it is said to be in *superior conjunction*. When the planet has swung out its farthest from the sun, as at $V2$ or $V4$, it is said to be at *greatest elongation, eastern or western*. Note that at this instant the angle at the planet in the triangle $S\,V2\,E$, or $S\,V4\,E$, is right. The angle

at E may be measured directly, or it may be obtained from a common almanac. Then assuming any desired scale for $S\,E$, a right triangle may be constructed on paper, having the angles E and S $(=90°-E)$ at the ends of $S\,E$. $S\,V2$, or $S\,V4$, will then denote the required distance. It may be measured by noting the mean time when Venus (or Mercury) crosses the meridian, and then converting the time interval into angle by multiplying the hours, minutes, and seconds by 15.

When $S\,E$ is known, $S\,V$ may be stated in miles. This same

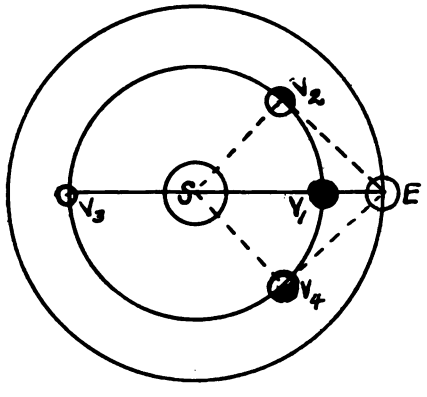


Fig. 32.

method holds good for either Mercury or Venus; but for no other planets.

Solve this problem both geometrically, by drawing to scale, and trigonometrically, using data of almanac.

Experiment XXXVI.

To find distance from sun to Mars, or to any planet whose orbit lies beyond that of the earth.

(The period of revolution of Mars is supposed to be known. Call it 687 days.) This may be found as for Moon Exp. XV.

At any instant measure the angle $S\,E1\,M$ at the earth between

the sun and Mars. Six hundred and eighty-seven days afterward Mars will be in the same place again, but the earth will have moved around twice, lacking 43.5 (2x365.25—687) days. Measure the angle $S\ E_1\ M$ at this time, and remembering that the earth moves over $360° \div 365\frac{1}{4}$ daily, we have only to multiply this by equal and known, a quadrilateral may be readily drawn to scale,

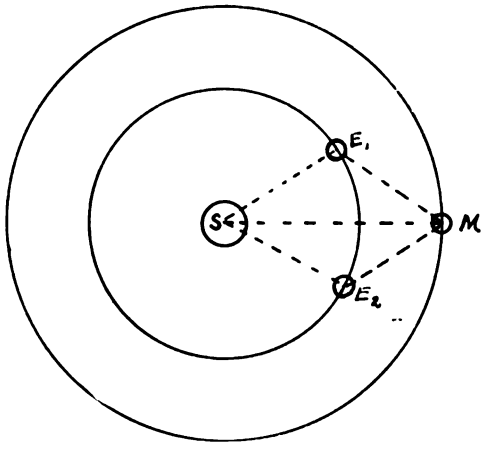


Fig. 33.

from which the straight line $M\ S$ may be read. Obviously, this process is applicable to any planet beyond the earth, as soon as its period is known, and this may be obtained by direct observation, as we hope to show later. Using observed data, or data of the *Ephemeris,* compute the distance from Mars to sun, and do same for other planets.

[NOTE: The last two experiments show how the distances of all the planets are made to depend upon the earth's distance by the simple geometric treatment of observational data. It is with the hope of getting the earth's distance more accurately than ever before that astronomers are giving so much work just now to the little planet called Eros. Whatever error remains in the earth's distance vitiates all other distances and dimensions, not only in the solar system, but throughout the stellar universe.]

Experiment XXXVII.

To find the distance from the sun to a star.

Let *S* represent the sun and *E*1 *M E*2 *N* the orbit of the earth. Let *B* denote the position of a star, say of Alpha Centauri. On a certain date the star *B* seen from *E*1 would be projected on the sky among the stars *C D E F*. Six months later the earth has been carried in its annual journey to *E*2 (186,000,000 miles from *E*1), and star *B* is then seen projected among the stars *G H J K*. This apparent displacement is measured by the arc *xy*, or by the angle *x By*=*E*1 *B E*2, and it is obviously due to the observer's 186,000,000-mile shift of position in space, and not to any real change of position of the star *B*. If an observer were supposed to be on *B* and looking toward the earth, and the line *E*1 *E*2 were

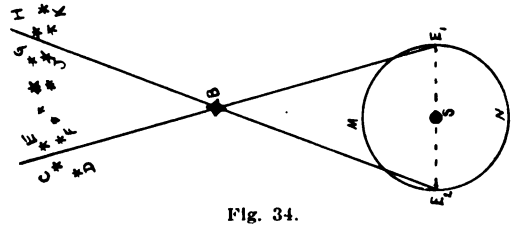


Fig. 34.

visible to him, we might say the angle *E*1 *B E*2 is the apparent angular diameter of the earth's orbit.

Now Experiment VII. taught us the law connecting the apparent angular dimensions of a line with its distance from the observer. Further experimenting would show us that if an object is viewed at a distance of 206,265 times its own dimensions it would open up an angle of one second of arc at the observer's eye. Experiment VII. shows that the apparent angle varies inversely as the distance. If the apparent angle is half a second, the object is 2x206,265 times its own dimensions from the observer, etc. Half of this angle *E*1 *B E*2 is called the star's *parallax*.

(To be continued.)

Metrology.

THE NATIONAL BUREAU OF STANDARDS.

BY RUFUS P. WILLIAMS.

(*Concluded from page 114.*)

(2) It is perhaps enough to say of barometers that all standardizing has to be done abroad, as in the case of thermometers.

(3) In many instruments an accurate standard is of great financial importance as well to government as to corporations. The annual duty on sugar, for example, amounts to some $60,000,000 and is based on the reading of the polariscope, an error of one-tenth of one per cent in the readings making a difference of $60,000 on the duty. A suit against the government has been pending for a long time. It hinges on the question of polariscopic reading, and there is no government standard to which to refer the quartz plates used in the readings.

(4) Photometric measurements are also of commercial value. The absence of a standard candle has forced one large electric company to establish a lamp-testing bureau of its own. From every barrel of 200 lamps sent the company ten are taken at random and if any one of these falls below 15 candlepower or is above 17, for a 16 candle, the entire barrel is rejected. But even these standards soon deteriorate and new ones must be obtained from experts. They, like the other standards, come from Germany. A similar test is made of the energy of consumption, five to six million lamps being annually tested by the bureau of this company. The lack of government standards has led to more serious results. The late Professor Rowland testified before the Congressional committee that a certain electrical association voted to call each arc light 2,000 candlepower (if it required 10 amperes of current at a pressure of 45 volts) when in reality it gave only from 400 to 500 candlepower. The consumer thus pays for and supposes he is getting a 2,000 candle light. Even if he knew better there would be no legal redress, for the law fails to define a candlepower as

regards electric lights. Our ideas and laws on this question come from England where many years ago, when gas was introduced in London, Parliament adopted as a standard candle one of definite composition which would burn 120 grains an hour with a government wick. The *incandescent* light companies in this country attempted to employ that standard, which is the legal one, as applied to gas.

(5) The revenue collected on liquors in the United States amounts to about $110,000,000 yearly and is based upon hydrometer readings, for which we have as yet no government instrument to refer to. Oils, acids and other liquids are similarly tested.

Enough has been said to indicate the great need, from a commercial as well as a scientific point, of a national standardizing bureau. Without going much into the history of similar institutions in Europe, let us refer briefly to one. Not to mention one of the earlier receptacles for standards in the British exchequer, nor to dwell on the International Bureau constituted in Paris in 1875—by reason of which France became the leading metrological nation of the world—we come to the more recent and best equipped of all standardizing plants, viz.: that of Germany. The commercial and manufacturing prestige which this latter country has lately developed is thought to be due in no small part to the accuracy and scope of its standardizing equipment. To the Reichsanstalt people have gone for instruments of precision, and German manufacturers have taken advantage of the accuracy of these to sell their wares to countries less favored. The Reichsanstalt is situated at Charlottenburg, a suburb of Berlin, and is the gift of Dr. Werner Siemens. Its general plan was outlined in 1887. It has two objects—research in pure science and the cultivation of precision in the technical application of science. The most distinguished physicist of the realm is sought as official manager. Helmholtz was the first incumbent, and at present Professor Kohlrausch is its head. The Reichanstalt has cost over a million dollars and there are nine buildings. Its annual maintenance costs $75,000 and 95 experts are employed. Papers of research work are published from time to time on various topics—heat, light, electrical work, chemistry and mechanical precision, such,

for example, as the investigation of the hydrogen thermometer, the thermal and electrical conductivity of pure metals from the temperature of liquid air up to 1,000° C. By the thermo-electric couple temperatures have been measured as high as 1,775° C., while with a petroleum-ether thermometer 190° C. below zero is obtained. Here are the most sensitive scales in the world. One

From PEARSON'S MAGAZINE.

THE REICHSANSTALT BUILDINGS AND GROUNDS.

of the two institutions under the control of the Reichanstalt for the calibration of thermometers has tested 350,000 during the last ten years.

England has lately created a bureau of its own on somewhat similar lines to the one in Germany. The bill for our own National Bureau of Standards was drawn up at the suggestion of Pres. Henry S. Pritchett by Dr. S. W. Stratton and others, and was approved March 3, 1901. A building site, consisting of some eight acres, has been selected in the northern suburbs of Washington on an elevation near Rock Creek Park, so situated as to be free from mechanical and electrical disturbances.

The two buildings to be first erected and the fittings are ex-

pected to cost $300,000 and to be ready for occupancy in about a year. Professor Samuel W. Stratton, formerly of The University of Chicago, has been appointed director. It is hoped to make this bureau second to no similar institution in the world. To it states, corporations and individuals may refer questions concerning all sorts of measurements.

Both directly and indirectly this bureau will exert a strong influence for the adoption and use of the metric system. It is probably the greatest step in that direction taken by Congress since 1866. The director and his corps of assistants—specialists of the highest training—will come in touch on the one hand with manufacturers of goods for both domestic and foreign consumption, and the latter means a constant reference to metric weights and measures; on the other hand they will render expert testimony to Congress in general and to the committee on coinage, weights and measures in particular. As scientific experts their influence will always be on the side of metric reform. Dr. Stratton recently said: "There is no doubt in the mind of any thinking person but that a universal system must soon be adopted, and no system offering advantages equal to that of the metric system has yet been devised."

NOTES.

From Melbourne, Australia.—Under date of April 4 there comes the welcome announcement that the Committee of the Federal House of Representatives has recommended the adoption of the decimal coinage system, based on the sovereign. Should this recommendation be adopted, there would be left only two important countries, Great Britain and India, with no semblance of a decimal system of coinage.

For and Against the Metric Bill.—The Metric Bill, referred to in the March number, was, on March 13, ordered favorably reported by the House Committee on Coinage. The hearings participated in by business men and large manufacturers elicited many opinions in favor of the bill and a few opposed to it. The chief objection appears to have come from a committee of the American Society of Mechanical Engineers, whose protest arises from the mistaken idea that the intent is to compel every citizen to use the metric system and to disuse the English. The final

clause of the bill, viz.: that *after January 1, 1907, the weights and measures of the metric system shall be the legal standard weights and measures of and in the United States,* is rather ambiguous, and ought to have been eliminated, but the attorney-general of the United States gives as his opinion that there is nothing in the bill which renders this use compulsory for anyone except government employes in government work. The only other objection worth noting was the cost of inaugurating the system in large manufacturing establishments. To quote from an editorial in the New York Tribune: "It is the belief of Director Stratton of the National Bureau of Standards that an erroneous impression prevails in regard to the cost of the change. There are two classes of manufacturers to be considered, he says. One produces wires, tubes, bars and plates, and, on adopting the metric system of measures, must make modifications of the dies and gauges now used. But since it is already customary to do so, to meet special orders, the practice is no novelty and involves no hardship. As for the second class of manufacturers, those who produce machinery, no change whatever will be required in the big and costly features of their plant—lathes, planers and milling machines. The reform will affect only what are known as 'small tools'—dies, taps, reamers and templets. Mr. Stratton is convinced that an exaggerated idea of the expense of this fresh equipment of a machine shop is generally entertained. . . . American manufacturers, who have been backward in this matter, but who cherish hopes of selling their wares abroad, should wake up to the fact that nearly all the foreign countries in which they are likely to find patronage have already adopted the metric system. There are other good reasons for assimilating the standards of this country to those of the world, but trade considerations alone justify the revolution. It is important that the change be voluntary and gradual, not obligatory and abrupt. Within these limitations, though the sooner it comes the better."

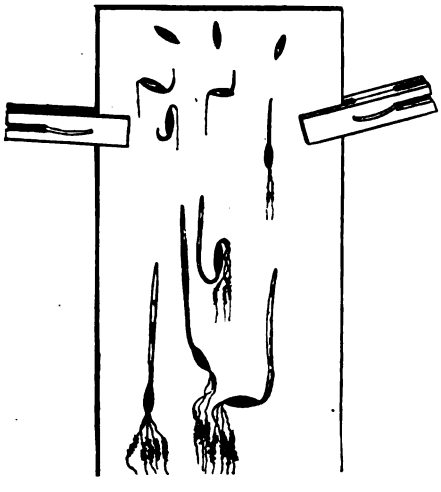
The Coinage Committee has issued an exhaustive Report of 240 pages, consisting of testimony at various hearings, and of letters from manufacturers and business men, which makes a strong document, almost wholly in favor of the bill. Every man who is interested in the metric system should now write to his Congressman and urge him to vote for the measure. The following is an exact copy of the bill:

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That on and after the first day of January, nineteen hundred and four, all the departments of the Government of the United States, in the transaction of all business requiring the use of weight and measurement, except in completing the survey of public lands, shall employ and use only the weights and measures of the metric system and on and after the first day of January, nineteen hundred and seven, the weights and measures of the metric system shall be the legal standard weights and measures of and in the United States."

Notes.

BOTANY.

An Instructive Seed Experiment.—Take two glass plates 5x10 in. and a sheet of heavy felt or carpet paper of the same size. Thoroughly wet the paper, place it on one of the plates and arrange on it a number of oat seeds in such a manner that some may be horizontal and some vertical (both erect and inverted). Place the second glass plate on the seed, after small fragments of the same paper have been inserted to prevent undue pressure. Clamp all together with four spring clothespins and insert one end in water.



This experiment shows many features of seed growth. *Root* and *stem direction,* effect of *varying amounts* of *moisture,* root-hairs (very fine), root-caps, etc. By inverting plate or placing it in a horizontal position other interesting and instructive phenomena may be noted.

Lake View High School, Chicago. H. S. Pepoon.

PHYSICS.

Record of the Disruptive Discharge of a Condenser.—An eight-inch test tube was moderately blackened over a smoky flame to within a short distance of its mouth and then inverted over the rod of a small retort stand. The base of the retort stand was connected with the outside coating of a battery of four Leyden jars. The battery was connected to the poles of a small induction machine, and, when charged as fully as possible, was discharged onto the bottom of the test tube. Ordinarily the spark this battery and machine would furnish, while not at all de-

ficient in quantity, would be only about an inch long. However, under these special conditions, the discharge took place the full length of the test tube with great violence and left the marks of its ramifications strongly outlined on the smoked surface, excepting occasionally when the tube was pierced. The record was then ready for immediate inspection by the class, or, when desired, was preserved by dipping the test tube into a weak alcoholic solution of shellac. Very curious and characteristic forms were thus secured and of a size not obtainable under ordinary conditions with the rather small machine used.

E. C. WOODRUFF.

PHYSIOLOGY.

Urea and uric-acid.—The idea is prevalent that these excreta are very poisonous, but modern research makes it certain that the toxic effects often ascribed to them are due instead to a group of imperfectly oxidized "alloxuric bases." Under normal conditions these poisonous bases undergo oxidation and form uric-acid, which is inert and harmless. The quantity of these poisonous bases contained in the circulation is regulated largely by the diet. Dr. Sajous, in his MONTHLY CYCLOPÆDIA OF PRACTICAL MEDICINE, enumerates the following foods which supply the body with an excess of these excreta: sweetbreads, brains, liver, kidneys, calf's feet, pig's feet, and the meats of *young* animals, such as veal, lamb, spring chicken, squab, etc. It is quite obvious that the effects of the alloxuric poisons can best be avoided by eating the flesh of the adult animals only and by supplying the body liberally with oxygen.

The International Sanitary Congress, which met last February in Havana, passed several resolutions of interest to all hygienists. They declared that the mosquito is the only means, so far demonstrated, of transmitting yellow fever, and recommended measures for exterminating mosquitoes. They advocated the formation of anti-leprosy leagues in every country, and the education of the masses concerning the contagiousness of leprosy and the best means of preventing infection. They also recommended similar leagues against tuberculosis. All countries where malaria exists are asked to make public the recent discoveries concerning the transmission of the disease by the mosquito, and to circulate printed matter on this subject in the public schools and among the people generally, in order that, if possible, the disease may be diminished.

Infection by flies adds one more peril to life. Since the publication by Dr. L. O. Howard, U. S. Entomologist, of his paper on the insects of human excrement, the dangers attending the visits of flies to houses and military camps, etc., are appreciated more than ever. There is no doubt that flies have conveyed typhoid fever to healthy persons, and how much more harm they may do by conveying contagion we can only imagine. The awakening of the public on this question ought to result in a more careful and scientific manner of storing, collecting and destroying garbage, especially horse manure, which is the favorite breeding ground for the common house-fly as well as other species.

Injurious athletics. Dr. Watson L. Savage, writing in the AMERICAN PHYSICAL EDUCATION REVIEW, recommends "that all games requiring a "continuous severe strain upon the heart of more than thirty seconds, "such as running, swimming, rowing, skating, cycling, tug-of-war, be "eliminated from the sports in our secondary schools, because: (1) They "are entirely unnecessary to the school. (2) They have little or no "educational value to the student. (3) They may abort the future capa- "bilities of the lad in athletics. (4) They endanger the health and future "life of the boy." Most of the other forms of school athletics are recommended.

FRANKLIN W. BARROWS.

Book Reviews.

Laboratory Exercises in Elementary Physics. By FRANKLIN H. AYRES. 14x19 cm., 193 pages. D. Appleton & Co., New York, 1901. 60 cents.

In the introductory pages, Mr. Ayres makes valuable and timely suggestions to the student as to the nature of his work, the importance of good records and the manner of making them. The pupil's attention is also called to the use made of variation and proportion in physical investigations and the principles of these subjects in which a majority of students exhibit a weakness are briefly discussed.

Then follow thirteen exercises in the use of instruments of measure, fifteen on the Mechanics of Solids, ten on the Mechanics of Fluids, ten

on Heat, twenty on Magnetism and Electricity, five on Sound, and eleven on Light—eighty-four in all.

This is a fairly equitable allotment of time to the different subjects, and as more experiments are given than the average class will be able to perform, there is afforded an opportunity for selection. The book closes with a set of twenty-four tables, giving all the data needed for reference and comparison.

The general plan of each exercise is to begin with an enumeration of the essential parts of the apparatus used; then follows a "Preliminary Discussion," stating the principles involved or giving a working definition or formula for the particular thing sought.

Next come very brief but explicit directions to the student as to what he should do and the order of doing.

Stress is laid on the importance of attending strictly to obtaining the experimental data, within the allotted time, while the apparatus is set up, avoiding all computations as far as possible, the latter constituting the next step in the work. Numerous queries are made to guide the student in making the proper deductions, inferences, etc. A logical sequence of operations is insisted upon, and the pupil is not perplexed by elaborate blank tabulations for data and results, but merely instructed to put his work in concise form.

The pupil is frequently cautioned to avoid certain general propensities that the experience of the author has shown obtain in certain connections.

Some teachers may object that Mr. Ayres tells the student too much in the way of definition and formulæ, preferring to hold the student responsible for these from the lecture room discussion of the subject, and to use the laboratory experiment as a test of the pupil's apprehension of the subject.

The work of the publisher is well done, the book being attractive in appearance, strongly bound, the type large and clear, and the illustrations of apparatus excellent. Altogether the book is a credit to its author, and, we trust, will meet a cordial reception at the hands of fellow teachers.

Instructor in Physics, City Schools, St. Joseph, Mo. J. S. Stokes.

Elementary Plant Physiology. By D. T. MacDougal, Ph. D. xii and 138 pages; 108 illustrations. Longmans, Green & Co., New York, 1902. $1.20.

The present volume is intended to take the place of an earlier work by the same author, of the same scope, and, though in a sense a second

edition of the "Experimental Plant Physiology," it is, nevertheless, an entirely new book, thoroughly up to date.

The increasing importance of work in plant physiology in elementary courses in botany both in school and college is, we think, a sign that it is becoming more and more a live subject. Teachers are coming to the opinion that a dynamic viewpoint in botany is the only one that can claim permanent recognition when dealing with their students. The plant as a thing of growth, action and change, is the central thought of a good course in elementary botany, whatever be the materials and methods chosen.

It is well, therefore, that both teacher and student be stimulated by a book, written by an acknowledged authority, which, though simple, is virile and pregnant with suggestion. And the book before us is such an one.

The first chapter deals with growth, a good starting point, since it emphasizes at once that we are dealing with change. We notice that the student's attention is directed to the observation of growth in all kinds of organs, rather than, as has heretofore most generally been done in elementary courses, to one organ, the root, or at best to root and stem. Reproduction and germination (of spores and seeds), the exchange and movements of gases and liquids are then taken up. Under the head of nutrition, the interesting and, economically considered, exceedingly important subject of symbiosis is briefly, though well treated.

The most important contribution to the literature of elementary teaching is the chapter which follows, treating of respiration, digestion and fermentation, and though brief, is very valuable. The reviewer has constantly used this phase of work in his classes and always with the most valuable results.* The closing chapter, on Stimulation and Correlation, turns the attention to the general facts of irritability, a subject of more obvious ecological import.

The general features of the book which appear to be especially worthy of note are the following:

Though primarily a treatment of physiology experimentally conducted, there is a constant and successful endeavor to give the work an ecological turn, so that the teacher will find it useful in conducting a course largely of ecology, if such happens to be the case.

The illustrations are, as they should be in every new text book, for the greater part new, or taken from recent foreign text books or from more recent monographs. This is one of the ways that your busy every-day teacher, cut off from large libraries, may be kept in partial touch with the recent work of botanists and catch some of the modern spirit. The cuts are clean, and the make-up of the whole good.

*"Botany in the Horace Mann School." *Teachers' College Record*, Vol. II, No. 1, pp. 41-45. January, 1901.

The author has a tendency to make use of quantitative experiments. This is definitely good, and it is a good pedagogical practice for teachers to follow this lead whenever possible. The experiments are nearly all simple, and require but inexpensive and readily obtained apparatus, though a very few are, perhaps, too difficult for the high school.

The introductory chapter contains suggestions and information as to material and apparatus, tables of weights and measures, and three "selected courses," which will undoubtedly be useful, in helping teachers whose experience may not be very great, in outlining courses of greater or less length.

F. E. LLOYD.

Reports of Meetings.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The fourteenth meeting of the Association was held on Saturday, April 5, 1902. In the morning, groups of the members visited the Union Glass Works, the Middlesex Bleach, Print and Dye Works, and the Chase Distillery—all located in Somerville, Mass. At noon the members were entertained by the President, Mr. R. P. Williams, at his home in North Cambridge. Luncheon was served and other courtesies rendered. An enjoyable feature of the President's hospitality was an opportunity to examine his collection of old chemistries and alchemies, several of them belonging to the sixteenth century. The afternoon session was held at Boylston Hall, the chemical laboratory of Harvard University. After the transaction of a few items of business, the Association was addressed by Professor Theodore W. Richards, of Harvard University, on "Theory and Practice of Determining Atomic Weights." The address, coming from one who has an international reputation in this field, was intensely interesting. A discussion followed, which was devoted largely to the interpretation of the Harvard entrance requirements in chemistry, stress being laid by Professor Richards on the point that Harvard expects a *good preparation*, but does not restrict the methods used to secure it.

Reported by LYMAN C. NEWELL.

NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

A meeting was held on April 4, 1902, in the Board of Education Building, Manhattan, President H. R. Linville in the chair. Miss Kate Burnett Hixon presented a paper, an abstract of which is as follows:

The Peter Cooper High School offers unusual facilities for field work on account of its situation. The last two periods of each school day are made use of at certain times for excursions to the nearby parks, the Aquarium, the Zoölogical Park or some of the vacant lots of the neighborhood. At least once a year the students are taken to the Botanical Gardens to study ecology, stems and their development, movements of leaves, etc. In zoölogical work certain known animals are studied with a view to finding out something first-hand of their life-habits and environment. The study of comparative anatomy and osteology is undertaken at the Museum of Natural History by means of printed questions.

Classes should always be directed by teachers in person. Definite questions given in the field should be followed by class discussions. Single class periods can be spent out of doors, if the material to be studied is near at hand. All trips should be obligatory. Best results are seen in the arousing of the powers of observation, creating a love for nature, and developing a feeling of *camcradie* between teacher and pupil.

Miss Mary D. Womack then read a paper, which is abstracted as follows:

The Grand Street Annex of the Wadleigh High School is situated in the most congested part of the city. Many of the girls have never been even to Central Park, and their ignorance of plant life is correspondingly great. To direct the pupils in field work, typewritten directions for the taking of interesting botanical and zoölogical trips are posted about the school building, giving the points of interest and cost of the trip. These directions are often illustrated. The expenses of the trip are defrayed by the pupils, one of their number acting as treasurer. The trips are obligatory. The students are required to make notes in the field, in studying plant societies, physiographic conditions, animals, birds, etc. Lantern lectures are given at the school in connection with the trips. Pupils are urged to work in the parks alone, and good results are obtained in this way as well as from trips in vacation. Preparatory to these trips, they are given general instructions as to what to notice and to write up in their note books. Field work is not only of importance in instruction to these girls, but also to their health.

In the informal discussion which ensued after the reading of these papers many good ideas were brought out. It was the general con-

sensus of opinion that field work is a valued adjunct of class work, and that at least one excursion should be made each term.

Reported by G. W. HUNTER JR., Secretary.

NATURAL SCIENCE ASSOCIATION OF ONTARIO.

The association met in annual convention at Toronto on April 1 and 2, 1902. The attendance was somewhat smaller than last year, but the interest was well sustained.

The President, Mr. G. A. Smith, of Parkdale Collegiate Institute, chose as the subject of his presidential address, "Some Palæontological Results." He outlined the history of palæontology in an attractive way and aroused much interest. A unanimous request was made for the publication in full of the paper in the Proceedings.

Prof. M. W. Doherty, of the Department of Entomology in the Ontario Agricultural College, Guelph, gave an account of the formation and work of the "Wellington Field Naturalists' Club." The club was organized to encourage the study of nature and to direct the efforts of those engaged in the study of natural history so as to secure the best results, and to record the results obtained. It is the intention of the club to hold an exhibition in the autumn, offering prizes for the best collections of insects, weeds, weed seeds, nature photographs, etc.

The secretary, Mr. E. L. Hill, Guelph, brought before the association the claims of SCHOOL SCIENCE. He pointed out that every number of this excellent periodical had contained articles of exceptional merit and of the greatest usefulness to science teachers who desired to keep abreast of the times. He also gave a brief review of some recent scientific books, strongly recommending Appleton's Twentieth Century series for school use, and Coulter & Chamberlain's "Seed Plants" for advanced work.

The Honorary President, W. Lash Miller, Ph. D., F. R. S. C., gave an admirable lecture in the Chemical Department of the University of Toronto, on "Chemical and Physical Change." This was illustrated by experiments illustrative of the reversing of chemical reaction by change of pressure, etc. Berthelot's Law of maximum work was shown to have been accepted in some cases because of the political power of its author, who had in his hands the appointing of chemists to many of the best positions in France. Dr. Miller created some amusement in offering an apology to the members of the Department of Physics (who were the guests of the Science Association), because a small quantity of hydric sulphide had escaped during an experiment. He stated that he understood that physics teachers were especially sensitive to that gas, carrying their dislike so far as to refrain from eating eggs lest their breath should tarnish the brass of the physical apparatus.

Mr. J. S. Plaskett, electrical expert of the University of Toronto,

gave an illustrated lecture on "Translation of Color into Monochrome by Photography." Mr. Plaskett showed the defects of ordinary plates, and the advantages secured by the use of isochromatic. He also exhibited some admirable examples of color-photography of his own production.

Mr. Carl Lehmann, of the Jarvis St. Collegiate Institute, Toronto, gave a description of the various methods employed in color-photography, and showed that it was possible by simple apparatus, to produce tolerably good color photographs.

Reported by E. L. HILL.

MICHIGAN SCHOOLMASTERS' CLUB—PHYSICS CONFERENCE.

The Conference met in the Lecture Room of the Physical Laboratory of the University of Michigan on the afternoons of March 28 and 29. The program as carried out was as follows:

1. The Laboratory Note Book: What? How? When? Discussed by Messrs. Bemis, Minchin, Morse, Randall, Ross and Slater.
2. The Concentration Cell. Prof. H. S. Carhart, Ann Arbor.
3. The Singing and the Speaking Arc. Prof. Karl E. Guthe, Ann Arbor.
4. The Physical Laboratory of the Joliet Township High School. Mr. Walter J. Risley, Joliet, Ill.
5. Purification of Mercury. Mr. W. H. Hawkes, Ann Arbor.
6. Pupin's Invention. Prof. G. W. Patterson, Ann Arbor.
7. The Nernst Lamp. Mr. C. W. Carman, Chicago.
8. Index of Refraction of Liquids. Mr. C. H. Slater, Pontiac.
9. An Optical Device for Compounding Simple Harmonic Motion. Mr. H. D. Minchin, Detroit.
10. Opaque Projection. Mr. C. W. Carman, Chicago.

The program proved to be one of unusual interest as shown by the large attendance during both sessions of the Conference. The discussion of the note-book question showed great divergence of opinion among teachers in the manner of its preparation. This difference of views was made still more apparent on comparing the sample note books of pupils' work that were exhibited. Prof. Carhart's talk on the Concentration Cell was an introduction to an investigation in which he is engaged that bids fair to overturn some of the modern theories regarding such cells. Dr. Guthe accompanied his paper by many surprising and interesting experiments with singing and speaking arcs. Prof. Patterson essayed a difficult task—to explain an intensely mathematical subject—to a non-mathematical audience. To say that he succeeded admirably is to state the facts very mildly.

At the business meeting the following officers were elected for the next conference: Chairman, Mr. C. F. Adams, Detroit; secretary, Mr.

F. R. Gorton, Ypsilanti; treasurer, Mr. C. H. Slater, Pontiac. A proposition to abandon the Physics Conference as an adjunct of the Michigan Schoolmasters' Club and to organize in its stead a Physics Section of the Michigan Academy of Science provoked a spirited discussion and revealed the fact that the great body of the members of the Conference was opposed to the measure.

Reported by H. N. CHUTE.

MICHIGAN SCHOOL MASTERS' CLUB.

CONFERENCE OF THE BIOLOGICAL SECTION.

(*Continued from page 127.*)

Joint Session with the Michigan Academy of Sciences.

In a paper on "Original Work for the High-School Teacher," Mr. E. L. Mosley, who has done so much for science in the Sandusky (O.) High School, gave a most striking illustration, a concrete example, of a piece of original work he had done in locating buried valleys of streams into Sandusky Bay. His boys accompanied him at one time or another, and one of them helped in the discovery of an old creek bottom that explained one of the problems that was at the time puzzling them. It was shown that such work may furnish a valuable basis for future engineering operations,....The conclusion reached was that the valleys now filled with mud and covered with water must have existed before the waters of Lake Erie had been raised so far westward, and that if this rise continued, ultimately Sandusky, Toledo, and then Chicago would be submerged.

Questions that might occur to a teacher wishing to take up original work were then discussed. To get a subject, a teacher may become a member of the local academy of sciences or attend the meeting of other scientific bodies. Local problems could be suggested by visiting scientists. "A desire to know is the best stimulus to investigation." Time for original work may be made by giving up other things...Both the desire to make money and the indisposition to spending it for scientific purposes must be curbed. Most of all is the preservation of health of the teacher; observation trips and the work of collecting for the classes will give the necessary exercise. Frequent change of position is detrimental, both to the interests of the school and most original work that the teacher might undertake. "The teacher of natural science who would imbue his pupils with the spirit of investigation should not be content to invoke their assistance in prosecuting his own researches. He should inspire them with a love of nature. To do this, he must take them into the country"....to see the things that cannot be brought to the school room.

In the discussion following, two of the University men held that it was difficult to find problems on which high-school teachers could work and that they did not usually have the time, though it was held that some sort of original work was almost essential for the best kind of teaching. Yet the principal speaker on this topic, a high-school teacher, had done very creditable science work, presenting at the opening of his paper an unfinished piece of work, which was original, to say the least.

Another member, however, presented a more encouraging view of this unpromising situation. He said the idea which holds teachers back from attempting original work is that they must do something great or nothing at all; but little things add to science. There are scientists in the state who wish to enlist teachers in small problems of distribution. Very simple things can be done along this line, which, in their broader meaning, may be very complex. The mere collection of material, when the locality is known, is of importance.

The description of "A New Biological Laboratory," by Professor S. O. Mast, of Hope College, was interesting, and as there are always some readers who may be prospective builders, a short account, with plans, is given on another page of this issue.

In discussing this paper, Miss Edith Pettee, of the Eastern High School, Detroit, gave a description of their new biological laboratory, and some of the principal features are here given, as it presents the high-school side of the same question. The laboratory is a large room, with three double windows on the north side. Before each of these is a large flat-iron-shaped table, seating eight pupils. A plate glass partition, nearly as large as the east end of the laboratory, separates the latter from the conservatory. This is of glass sides and top, with cement floor. An aquarium table stands in the center. The plant benches are around the sides, covered with metal and lined with asbestos. The steam pipes are under these—not a satisfactory way. At the opposite end of the laboratory is a recitation room. At the side of the laboratory is a small store room, which also contains a small hot water heater, to supply hot water faucets in the laboratory sink. There are cases for books and apparatus in the laboratory room.

In a short talk on "Methods by which new Varieties of Cultivated Plants are Originated," Professor C. F. Wheeler, of the Michigan Agricultural College, gave many ways in which the horticulturist produces such interesting results. Some new products were mentioned—a daisy, four inches across, will soon be common property. In illustration of the ability of plants to vary with their surroundings, it was said that the "dented corn" of the South may be changed to the "flint corn" of the North after three years' planting in the latter latitude. In the discussion that followed, Professor Davis called attention to the fact that the garden radish, the cabbage and the cauliflower were the result of

selection acting on the plants of the mustard family that had, respectively, somewhat thickened roots, or leaves, or flower-stalks.

Mr. J. W. Matthews, of the Western High School, Detroit, then spoke on "The Kind of Zoölogy for High-School Work," saying in substance: The discussion of the subject of zoölogy in the high school should answer three questions: Why study zoölogy in the high school? When shall it come in the course of study? What shall be the branch of zoölogy presented.

There is no study in the curriculum that can produce better development of the powers of observation, comparison, and classification. No other subject gives such natural material for the development of observation, which is the first step in all study; and comparison, which establishes the facts thus gained; and classification, the logical conclusion. Pupils readily feel at this age the philosophy of the general laws of life, and need the breadth given to thought by considering human life in connection with animal life.

The best time for zoölogy is the second year of the high-school course; following a year of botany, which shall have consisted of the study of plants as a whole, their habitats, when they flower, their method of flowering, their uses, etc. In fact, much work in "God's laboratory" rather than confinement within the walls of a building with expensive apparatus and a few plants. A high school following such a plan for five years sent out six students who specialized in biology and were chosen assistants in the University of Michigan; four others, who went from college to teach biology in the public schools, or to follow lines of nature work; thus making ten pupils in that period of time inspired to choose life work in biology.

The conference closed with a lecture on "The Germicidal Action of Metals and Sunlight," by Dr. F. G. Novy, of the University of Michigan. On account of his researches along this line, much interest was taken in what was said, an abstract of which is here presented:—

The surface or contact action of metals has been studied by chemists for many years. It is well known that certain metals, as platinum, and especially palladium, absorb relatively enormous volumes of hydrogen. The gas is held in combination with the metal and is easily given off in a dissociated or active condition. As a result, palladium-hydrogen is capable of exerting a marked oxidizing action. It may convert, as Hoppe-Seyler pointed out, benzol into phenol, aldehydes into acids, liberate iodine from potassium iodide, etc. Moreover, hydrogen peroxide is formed when it is brought into contact with water.

The contact action of platinum is especially seen in the manufacture of fuming sulphuric acid by the new method. When platinized asbestos at a high temperature is brought into contact with oxygen and sulphur dioxide, the metal acts as an oxygen carrier and the result is the formation

of sulphur trioxide or sulphuric acid. By this procedure it is possible to prepare pure fuming sulphuric acid, and it is more than likely that the "lead chamber" method of manufacture will be entirely done away with.

In 1889, Dr. Miller, the well known American dentist of Berlin, showed that certain metals, such as gold and copper, exerted a marked germicidal action when brought into contact with bacteria. He explained this action as probably due to oxygen condensation on the surface of the metal. Behring, the discoverer of diphtheria antitoxine, repeated and confirmed Miller's experiments, but the explanation which he offered was very different. He held that the bacteria, by means of their soluble chemical products, dissolved traces of the metals and that thus the germicidal action was brought about. In their studies upon the formation of organic peroxides, Drs. Freer and Novy showed that these substances are readily formed when some metal or even fabric was introduced into the mixture of the ingredients. In other words, the surface or contact action of metals was manifested in much the same way as in the manufacture of sulphuric acid by means of contact with platinum. The view was expressed that probably the germicidal action of metals was due, not so much to the solution of the metal employed, as to the formation of peroxides by surface action.

It is well known that sunlight is destructive to bacteria, and the only explanation from a chemical standpoint which has been heretofore brought forward is that hydrogen peroxide is formed under the influence of the sun's rays. There can be very little doubt about the formation of this substance under those conditions, but the amount that is present is hardly sufficient to account for the rapid and intense germicidal action observed. The ultra violet rays are especially active in this regard. The explanation of the action of the sun's rays must be due either to the formation of powerful organic peroxides, such as those described by Drs. Freer and Novy, or to ionization. Investigations along these lines are now being carried on in the Hygienic Laboratory of the University.

Reported by L. MUHBACH.

DISCUSSION OF QUESTIONS.

37. What cases of chemical arithmetic should a senior class in high school be required to master?

The solution of problems in chemical arithmetic demands three things of students: (1) A knowledge of numbers. (2) Familiarity with arithmetical and simple algebraical operations, and (3) Ability to perceive relations. The first requisite may safely be assumed, but the second, elementary as it is, can by no means be taken for granted. Every year a portion of my class is utterly unable to solve simple examples

in percentage and in proportion, to say nothing of being slow, careless and inaccurate in employing the four fundamental operations. The third requisite is never acquired by some, is seldom possessed by many at the beginning, and seems to be desired by few. I hope all teachers are not confronted by similar conditions, though some have expressed their convictions in about this way. But the situation is not hopeless, because we know the defects. Those students who are strangers to the simple operations are turned over to the teacher of mathematics for definite instruction in those processes demanded in the solution of chemical problems. They may have never learned percentage and proportion in the grammar school. As a rule, teachers of mathematics are willing to assist students with a real difficulty. It is the "eternally stupid" ones who see nothing at all in mathematics whom he does not wish to take his time. The third requisite—ability to perceive relations—may be acquired by students by a judicious performance of these rules: (1) *Practice reading problems.* Select the thoughts from the statement. Often relations are not perceived because the language is not comprehended. Get the kernel from the shell. See mentally what the problem means before giving a single thought to its solution. This is especially desirable with problems involving equations, particularly when both weight and volume are to be considered. (2) *Indicate the solution without performing the work.* This plan fixes the attention on one thing, viz.: the relation of parts. The mind is not bothered with numbers, and can therefore concentrate on the part to which thought must really be given. (3) *Forecast the answer and, if possible, its approximate value.* This operation is not difficult. It often reveals relations very quickly. It is eminently practical, and is employed in many industries. It likewise trains one to be a quick worker. Such a plan is applicable to problems involving metric transformations, corrections for pressure and temperature applied to gas volumes and density.

Teachers who assist students along the lines suggested will find their labors lighter as the subject advances. Problems will not be so distasteful, nor will students regard them as extra burdens. It is advisable also to connect the problems with the laboratory work. Let them arise naturally from experiments. This plan may be followed in many cases. A class instructed from this standpoint should be able to perform in their fourth year of general high-school work problems involving (*a*) the metric transformations, (*b*) Boyle's Law, (*c*) Charles' Law, (*d*) correction of gas volumes for pressure, temperature, and water vapor, (*e*) percentage composition, (*f*) deduction of simplest formula from percentage composition, (*g*) all questions arising from *known* equations, (*h*) density and molecular weight, (*i*) simple atomic weight determinations, (*j*) combination of gases by volume.

LYMAN C. NEWELL.

School Science

VOL. II] OCTOBER, 1902. [NO. 4

THE TEACHING OF SCIENCE.*

BY WILLIAM HARMON NORTON.

Professor of Geology, Cornell College, Iowa.

In suggesting a few of the functions of science teaching I shall not attempt to arrange them in the order of their importance. In fact, the first one I shall mention is the one which probably is least often in our thought—the discovery and training of scientific aptitudes. In a broad sense education is the transmission of the world's knowledge from one generation to another. This rich inheritance cannot be conveyed by libraries and museums or in any mechanical way. It can be handed on unimpaired only by training men capable of receiving and using it. Do the Vanderbilts and the Rothschilds take all possible pains in the technical education of their sons in the management of their vast railway and banking properties? How much more does it concern us to see to the training of the men of science of the future, the heirs of its wealth! Somewhere in our schools today are the Rowlands, the Asa Grays, the Maria Mitchells and the James Halls of the next generation. There, too, are the thousands of the rank and file who are to do their humbler work in winning the scientific victories of the future. It was in an old log school house that the genius of Mendenhall was awakened by a good Quaker lady who had the way of setting her pupils to making simple experiments in physics. Early in the last century an eminent botanist at the University of Cambridge took one of his students into so intimate a friendship that the young man was known among his

*Presidential Address, Department of Science Instruction, National Educational Association, Minneapolis Meeting.

fellows as the one who walks with Professor Henslow. He had been considered a very ordinary boy indeed. His classical schooling, as he himself tells us, had omitted all habits of observation and reasoning. But Henslow discovers the marvelous scientific aptitudes of young Darwin, he secures him place as naturalist on the ship Beagle, and to the friendship of that teacher the great biologist attributes "more influence on his career than any other."

Whether in country school or in college, the teacher who discovers talent to itself, who directs it to its goal and helps it on its way, may be doing his generation a greater service than the munificent endowment which is to deport American students to the ancient University of Oxford.

It may possibly be true that genius does not need to be discovered, that it will blaze forth from beneath any smother of adverse circumstances. Possibly Rowland would yet have been Rowland even if his father had refused to listen to his pathetic cry at classical Andover—"O, take me home!" and had not removed him to the congenial environment of the Rennselaer Polytechnic. But without question the great majority of workers in science owe their efficiency to those whom this department represents. Apart from science instruction their scientific aptitudes would never have come to fruitage. For faculties which in childhood give every promise of large development may be so repressed during adolescence that they are stunted forever. How much science should there be in our schools? Enough so that all the way from primary school to university there shall never be a single year in which the scientific aptitudes of our students may not be developed by the study of nature at first hand.

These boys in our classes who are to be leaders in science are probably not particularly brilliant boys. They may not shine in recitation as do those young intellects which are made with the capacity of the gelatine copying pad and can as faithfully reproduce the phrases of the text. They may ask inconvenient questions; they certainly have a high degree of individual initiative; they may be restive under routine. But in the field and in the laboratory we shall discover in them a marked ability to see, to coördinate and to interpret.

Let me suggest that we enter sympathetically into whatever scientific interests of our boys may at the time be strongest. If they are in the collecting stage, we may gently divert them from postage stamps to flowers or fossils, or butterflies; we may see that the collections are studied with something of the care that Oswald Heer gave his insects, and which made the cabinet of young Spencer Baird the nucleus of the collections of the Smithsonian Institution. It may be that we shall find in our boys a greater liking for their furry and finned and feathered friends alive and at home than dead and on the dissecting table. Then let us see that the laboratory does not repress this normal turning of the young naturalist to out-of-door study.

I do not mean to imply that the cadets of science need be given instruction of a sort different from that of their fellows. The teaching which best brings out scientific aptitudes is only that which every student should have; it is that which performs the second function of science instruction; it brings in touch with Nature. Science teaching is objective, its impressions are at first hand, it brings face to face with facts. How weak and vague, how illusory and fleeting, is the impression of the word compared with that of the thing. It is our peculiar privilege to teach things, not words. In this presence I need not slay again the slain and say aught against the bookish teaching of science. After all it is probably as worth while as the bookish teaching of anything else. I do not know why "Fourteen Weeks" in physics or in geology in the high school is not as valuable as fourteen weeks in Grecian history or political economy. But the text-book teaching of science is so markedly inferior to the laboratory method that it is fast disappearing from our schools. In chemistry, physics, and biology it has well nigh gone. But in the earth sciences the use of new and fruitful methods of study in the laboratory and field has hardly more than begun. How many well equipped physiographic laboratories can any of us count in his own state in colleges and normal schools and universities, to say nothing of high schools? And in how many public schools are such fundamental notions as the weathering of rocks and the work of streams still taught from the printed page, instead of

in the field. Last Fall I asked the students in my different courses in geology in Cornell College how many of them had ever, when in high school or academy, taken an excursion in geography or physiography. And there were only four, out of my one hundred and twenty students, who had ever been taught anything in these two subjects outside the schoolroom. Professor Shaler of Harvard tells of an enthusiastic visitor at the Peabody Museum, who was so anxious to handle the feldspars in one of the cases, because she had been teaching feldspar to her pupils for fourteen years and had never before seen the mineral to know it. Her type, I fear, is not extinct. No matter what or how much we omit from the text, let us teach first and foremost, as critically and as fully as possible, whatever can be seen and handled, drawn and described, and verified by experiment. We may leave to others to teach the conning of the printed page, and the assimilation and the reproduction of its ideas. It rests with us to train the quick eye and the skilful hand, to teach the patient investigation of Nature. I once asked Dr. Alexander Winchell if he found his seniors at the University of Michigan good observers. "Yes," he answered, "if they have not had too much Latin and Greek." Apart from science studies a college course may easily dim the eye and leave one a duller student of things than when he entered. If science is rightly taught in our schools no one need ever say, as the distinguished president of an American university once confessed: "The best teacher I ever had was the kindly old neighborhood loafer, who roamed the woods with me and told me the times of the wild flowers and the habits of the birds."

It is because scientific culture is objective that it has an ethical value wholly different from that of any culture largely subjective, such as literature, art, or philosophy. Edward Everett Hale has told of the good he got when a boy from setting type in his father's office. "The absolute accuracy which is necessary is good for a boy. The solid fact that 144 ems will go in a given space, and will require that space, and that no prayers nor tears, nor hopes nor fears will change that solid fact—this is most important." Here we touch the special function of science training. It teaches limits and bounds, the bounds of the solid fact. In

literary culture the spirit projects itself into the world. It fuses, I might almost say, external reality by the breath of phantasy and reforms it according to its own free creative power. But science faces the spirit with adamantine walls, the unchangeable *moenia mundi*, Its God is the God of things as they are, not of things as we might imagine them to be. Its work is patiently to investigate and humbly to obey. Science, therefore, teaches fairness, emancipation from prejudice and personal bias, and a supreme love of the truth. Its word is not freedom, but law. Everywhere it teaches law, and the inescapable consequences of its breaking.

Despite the rapid upward curve in the scope and effectiveness of science instruction, it was perhaps never more needed than now. We are all of us acquainted with estimable people, cultured and lovely women, graduates of our high schools and colleges, though seldom, I believe, in scientific courses, who have come under the spell of the recrudescence of an ancient delusion. They have been, as they say, "set free." To them there are no solid facts. "Do not teach physiology in the schools for the dear children really haven't any bodies," was the substance of their petition to the school board in one of the largest of the cities of Iowa. It is their faith that they can change at will this old world of ours and annihilate all its cares and pains and disease. I know of nothing which will render our pupils immune to such vagaries except a continuous treatment of physical science administered in large doses. Let me emphasize the fact that because of its touch with external reality, because it teaches the veracity of the world, the discipline of science is preëminently serious, healthful and sane.

All this is intimately related with the last function of science teaching which I shall take time to mention: the discipline of the reason. Language with its vocabularies and paradigms, literature with its imaginative interpretations, with its supreme sense of beauty and of form, rather than of substance and of truth, indispensable as they both are to a liberal education, cannot develop the rational faculty. For this we must ever depend on the strenuous athletics of mathematics and science. What geometry is as an educational instrument in deduction, that the inductive sciences may be made in training the reason to deal

with the concrete facts of daily life. They demand as a daily exercise comparison, judgment, reasoning from cause to effect and from effect to cause, the sifting of evidence, the testing of hypotheses, the calculus of probabilities. If the teachers of America can teach the scientific method to the rising generation, no other war need be made on superstition and credulity. The epoch of patent medicine and the weather prophet will pass to join that of the amulet and the wizard. The rooms of our large hotels will include the "13s," and Friday will no longer be unlucky. Science instruction will have rationalized the social mind.

It was once said by Robert Louis Stevenson—that consummate artist in words—"No one knows better than I that, as we go on in life, we must part from prettiness and the graces." The time has come when in education prettiness and the graces must at least be made subordinate. Secondary and higher education may be likened to the pillars of Solomon's porch. Wrought of solid metal and crowned with chapiters of carven pomegranates and lily work, they were fitly named *Jachin,* He shall Establish, and *Boaz,* In it is Strength. However rich may be the decorative beauty of the education of the future, I believe it will be established in the strength of science. If the understanding is more than the imagination, if truth is more than beauty, science must needs be the central supporting column of all education after the reason has come in its development to surpass the faculties of earlier ripening.

It is the core of science which must save American culture from decadence. There have been, there are, decadent cultures as there are decadent nations. Let me cite the chief historic examples:

The culture of the rhetoricians of Greece, a culture which concerned itself solely with words and the manners of public address, and which at last made the very name of its teachers, the sophists, a byword to future generations.

The culture of the last century of the Roman empire, a culture which devoted itself solely to the study and imitation of models of a literature at that time ancient, and was therefore smitten with barrenness even in the field of letters.

The culture of the English universities within the memory

of men now living, "caravanseries of idlesse," in the phrase of a distinguished graduate of one of them, where the flame of thought was fed with the ashes of ancient studies from which the life had long since been burned out.

The culture of the universities of India today, a culture which the London Spectator recently called "a rotten culture," which teaches the Bengali the masterpieces of English as the Roman was taught the masterpieces of Greek and, "indifferent as it is to science and the constructive arts is ultimately to fall, and probably with a crash."

The culture of China, a culture classical in the veneration of the ancient models of its literature, and exquisite in the cultivation of the amenities of speech, a culture which excluded science from the empire by imperial edict, and which more than any other internal cause is bringing to pass the dissolution of that venerable nation.

The strain of weakness in all these decadent cultures is clear. They make no provision for the education of the rational faculty of man through study of his physical environment. But we need apprehend no similar fate for education in America. It is woven of too many strands. A culture which teaches literature—the highest expression of the thought of the world; history—the social evolution of man; and science—the knowledge of the laws of nature, of self and of society—cannot die except with the death of civilization itself.

THE SCIENCE TEACHER AS A PUBLIC BENEFACTOR.

BY A. C. NORRIS,

Instructor in Science, East Side High School, Green Bay, Wis.

It is assumed in this article that the teacher is thoroughly interested in his work, and is master of his subject. For what is more distressing than a half interested, poorly prepared science teacher?

It is true that the teacher of English and history can be of great help to the school literary society. The teacher of language

may get his pupils thoroughly alive to the great problems of literature and philology. The teacher of the commercial branches need not take a back seat when interest is to be aroused. But how much greater is the field of the science department!

In order to be of help to anyone we have to secure their acquaintance and friendship. Mr. E. L. Morris, in the January number of this journal, has a very able article along this line. Our laboratories should always be open to visitors. We should show them around. If possible, have a lung tester, electric pendulum, telegraph system, aquarium and museum always on exhibition. They will go away feeling well repaid for their visit, and, when speaking of the school, they will not forget to mention the laboratory. When a school teacher can get a whole lot of people talking favorably about his work, he has been far from unsuccessful.

If you are teaching in a high school, do not forget the grades. Many a boy or girl has remained in school because he has a desire to study chemistry or botany. If you have a vacant period take some simple piece of apparatus and step into the sixth or seventh grades and explain it to them. Make your explanation short and clear, and they will beg you to come again. They will even repay you by bringing you specimens. Our laboratory is full of rocks, birds' nests, hornets' nests, frogs and even snakes brought in by the grades. Instead of going to the grades yourself, a better plan is to have the teacher come to you and get apparatus. The children will know that it comes from the laboratory and the same result will be obtained, without any embarassment to the teacher as to your superior knowledge. Occasionally put forth your efforts to bring a scientific lecture or entertainment to your town or city. Have liquid air, X-rays or wireless telegraphy been in your town lately? If not, make an effort to secure them. Sell tickets yourself. Get acquainted with the people and let them see that you mean business. You will gain friends and have more influence as a result of your efforts.

Use every opportunity to teach by practical illustration. Take your physics class to the sawmill, electric light plant or telegraph office. With your zoölogy class, visit the meat and fish markets, the zoo or a well-kept sales stable. Get them so interested in their

work that they will pick out every scientific principle as it presents itself to them in their everyday life.

Last, but not least, make yourself a valuable member of society. Teach the minister or lawyer photography. Offer your services and apparatus to the lodge or society that is going to give an entertainment. Be on hand when the football player gets hurt, and apply the principles you teach in physiology. Write an occasional article for the local press upon some current scientific topic. And finally do all these things with as little show and glitter as possible, and you will never have to look for a position.

THE HISTORY OF ZOOLOGY TEACHING IN THE SECONDARY SCHOOLS OF THE UNITED STATES.*

BY MARION R. BROWN,

The Erasmus Hall High School, Brooklyn, N. Y.

[A contribution from the Department of Biology, Teachers' College, Columbia University.]

With the dawn of the nineteenth century biology was introduced into the secondary school curricula of the United States. Previous to this time it had held a minor place in European schools, but received no recognition on this side of the Atlantic. Its introduction into America is to be attributed to the broadening conception of the meaning and function of education which prevailed in the country after the Revolution and which expressed itself institutionally in the founding of academies, more liberal in both aim and subject matter than the earlier grammar schools had been. The introduction of biology cannot be connected directly with the founding of these academies except in so far as both are the result of one cause; for during the first quarter of the century it was confined within the limits of female seminaries and "to classes collected especially for hearing lectures on that subject." Even in these places botany alone was taught, being regarded as preferable to zoölogy by reason of its being "more attractive, elegant and precise, so well adapted to the refinement of female education." The precedence thus gained by botany over zoölogy it has maintained to the present day.

*Essay presented for the degree of Master of Arts, Columbia University, 1901.

About 1825 zoölogy first made its way into the curriculum. In aim, subject and method it resembled but slightly the zoölogy of the present. Its intrinsic value in broadening and training the mind was no part of the purpose of its introduction, but rather to acquaint children with the works of the Creator and inspire them with love and admiration for a Being who could and did create such great and wonderful things for the children of men. All sciences were taught more or less with this end in view, but none, perhaps, unless it be astronomy, was calculated so effectually to accomplish the purpose as biology. Just here may be noted again the unity of purpose in the teaching of biology and the founding of academies in that both laid great stress on moral and religious training. This attitude toward the subject continued until about 1850, when it was gradually replaced by a more scientific and intellectual spirit. During this early period the subject was taught in but few schools. Public and common schools excluded it entirely from their curricula. The cause of this was the mistake prevalent in so many communities of its inutility. It was looked upon as an accomplishment inapplicable to the sterner duties of life. Views of utility and immediate practical good predominated over other educational aims, and consequently natural history was excluded. Private schools paid but limited attention to it, not even so much as was paid to natural philosophy. The reason for this lay not so much in the inutility of the subject as in the lack of proper facilities, teachers, books and instruments for carrying it on. For lack of these the student became disgusted with the technicalities and theories before reaching the point where his interest and curiosity would be aroused. The method of presentation of the subject was to have the pupil memorize a certain number of pages of some textbook. Specimens, if studied at all, were used to verify statements in the book, and were less used in zoölogy than in botany, because of the nature of the subject matter. Animals lent themselves more readily to the natural history point of view, and consequently less attention was paid to their anatomy. There were no good textbooks to further even this rudimentary work. All that then existed were defective, primarily because of their untruthfulness, and secondarily because

they were translations and reprints of foreign books, which, without alteration, had been put into the hands of students. These taught about objects foreign to the pupils' environment and gave them no direct personal introduction to nature itself.

Of the defects of the method just described many of that time were well aware, and in 1837 John Lewis Russel delivered before the American Institute of Instruction at Worcester, Mass., a lecture on the "Study of Natural History." This is the first address in this country upon the subject of natural history which appears to be extant at the present day. Other addresses of earlier date, notably in the American Annals of Education for 1831, contain references to biology as a subject which has held a minor place in a few school curricula for several years. These references, however, seem to make special mention of botany, from which we may infer that zoölogy was but little studied at that date. Even at this early date we find men who deprecated the then present methods and advocated others which, in the light of modern science, have proved to be far better, for we find the claim was made in certain quarters that the only way to study natural history is to turn to nature and receive knowledge first hand. The pupil must be interested by the facts and not by abstract problems. Such interest was considered by some people adequate to prevent vice by furnishing innocent amusement and relaxation by "illuming the path of duty with the light of science." Natural history could be made a powerful instrument in the hands of Christian teachers for bringing the young "through nature to nature's God."

The history of zoölogy in secondary teaching may be divided into four periods, with their approximate dates as follows: (1) 1825-1870, a period characterized by the natural history phase of the subject, taught according to the textbook method; (2) 1870-1886, in which comparative anatomy was made the basis for work and the textbook was supplemented by verification by specimens; (3) 1886-1900, during which time comparative anatomy continued as a basis for work, but real laboratory work was introduced and the scientific world was flooded with laboratory manuals; (4) from 1900 on there has been a gradual tendency to combine the natural history phase with the comparative anatomy of the two pre-

ceding periods. This work is conducted by the laboratory method and field work. The time divisions must not, however, be regarded as strict, but as delineating in an approximate way the stages of change in teaching.

The surest indications of the tendencies of a given period are the textbooks. These, however, follow instead of lead the onward movement of method. They are written to supply a demand, rather than as an inspiration and guide to progress. The earliest textbooks were translations of foreign works, and amongst the earliest of these was Ruschenberger's series. These books were prepared from the text of Milne Edwards and Achille Comte, professors of natural history in the colleges of Henry IV. and Charlemagne, by W. S. W. Ruschenberger, M. D., a surgeon in the United States army and a member of the Academy of Natural Sciences of Philadelphia. The books were written from the physician's standpoint, and base the study of the whole animal kingdom on the anatomy and physiology of man. They deal principally with the natural history of a vast number of animals, beginning with the highest forms. Classification is the basis of all study, and is taught arbitrarily in the beginning of the work before the student has any conception of its meaning. Anatomy is treated only in connection with the higher animals, and there is confined almost entirely to external features. Birds are dealt with in regard to internal structure. That these books, six in all, supplied a keenly felt demand is shown by the fact that five editions of the first one were published during the first year, that it was introduced into the schools of Philadelphia and into nearly all first-class seminaries, and that this was followed by five more books during the four succeeding years. The method by which these books were to be used is clearly set forth in the preface. The double purpose of the study of natural history is "to impart certainty to the mind and religion to the heart." This is to be acquired by thorough mastery of the facts of natural history as set forth in books, related by teachers and gathered from visits to museums and collections. "Only thus can one become a true naturalist." The tendency toward a broader view of the study, as outlined by Mr. Russel in his address previously referred to, is recognized by the

author. Ruschenberger states in his book on Mammalogy, published in 1842, that "It is contended that natural history is best studied without the use of any books whatever, except the book of nature and its visible illustrations. This notion is entertained by persons of so much learning and influence that it is worth our while to inquire briefly whether the plan has pretensions that should lead to its general adoption." This method apparently does not meet with his own advocacy, for he urges rather the use of textbooks, lectures and oral instruction supplemented by verification in museums.

Other textbooks of this period illustrate the same general tendencies. All are written strictly from the natural history side and emphasize the religious purpose of natural history study. The value of the subject as a means of disciplining the mental powers is claimed about 1860 by Mr. Hooker, who says that for this purpose science is as valuable as mathematics or language. It cultivates the perceptive and reasoning powers together, thus forming the habit of intelligent observation. This would indicate a deviation from the stereotyped method of recitation by supplementing the memory work with observation of natural objects, and is probably the first recognition of the value of Pestalozzi's theory of object lessons in zoölogy work. Certain other changes are also to be noted which are shared by all textbooks of the time, i. e.: (1) condensation of material into one book which placed the possibility of purchase within the pupils' means and increased the convenience of both teachers and pupils, (2) introduction of the geographical distribution of animals, (3) increasing emphasis on the economical value of the study, (4) copiousness of illustrations. As representative books of these years, up to 1870, may be mentioned Chamber's "Elements of Zoölogy," Hooker's "Natural History" and Tenney's "Natural History," published respectively in 1847, 1860 and 1866. The arrangement of all of these is strictly systematic, beginning in each case with man and going down the scale of animal life to the protozoa. The introductory chapter in each book takes up the principles of classification and divides the larger groups as low as families. Cuvier's plan is followed. Vertebrates occupy considerably more than half the book in each

case. The first two, Chamber's and Hooker's, offer aid to the teacher by a set of questions at the foot of each page, which show how closely the pupil was expected to confine himself to the text. Current periodicals during the years 1860-1870 indicate at least an appreciation and hope of better work in natural science in the future. In the *New York Teacher* for January, 1864, we read: "The current is setting strongly in favor of more general study of natural science in our schools. A few years ago hardly any attention was given to it even in high schools. Now too often it is crowded into the last year of the course." Such a position argued well for future progress.

The second period in the development of natural history covered about sixteen years. A decided step forward is to be noted in the broader and more appreciative conception of the value of the subject in the uses which it might subserve, and in the change in the method of presenting the subject to accomplish these newly acknowledged aims. During the preceding decade long continued criticism of the old teaching system had begun strongly to affect the public mind, and now natural science was gladly admitted to the schools, and, as was remarked by Prof. N. S. Shaler, of Harvard, was "even unreasonably welcomed as a deliverer from all the great difficulties of education." It was, however, not yet recognized as one of the essential factors of education, because it was not widely enough known, and because of the prevailing impression that it did not offer so broad a scope for mind discipline as the classics, mathematics or philosophy, which had centuries of use to support their claims. Time is necessary to accustom the public to new educational as well as other new ideas, and natural history was only slowly winning its way to favor. It endeavored to cultivate and encourage the power of observation, habits of precision and elegance in speech and to aid in securing a good vocabulary. It aimed to give students an accurate knowledge of the phenomena of nature and of the laws governing nature. The earlier desire to bring pupils nearer to the Creator had not entirely passed away, but the earlier religious ideals had been replaced by a more practical aim.

The natural history side of animal life was plainly declining

and morphology was taking its place. Classification was still closely adhered to, but was not taught as the foundation on which all other study rested. As Mr. Morse explains in his textbook, when he places it at the end, "There is no use in studying classification until the pupils know something to classify." There was also a reversal in the order in which the various groups were taken up. Darwin's theory of evolution and a better knowledge of the lower forms of animal life had led to more attention to lower forms and had undoubtedly been influential in causing this reversal in the order of treatment. The most potent influence in shaping the work of this period was Louis Agassiz. From the little island of Penikese his influence had spread to the colleges and universities and from there to the secondary schools. Accurate observation and classification to discover "natural affinities" came to be more and more the aim and "comparison" the method of study in zoölogy. For two reasons Darwin's careful analysis and explanations had less influence in secondary work than Agassiz' "love for nature." (1) They were less adapted; (2) Agassiz was in America, Darwin was in England. There was no direct effort to teach evolution as far as I have been able to observe, but there was greater attention given to comparative morphology. The lower forms were treated almost entirely from the morphological standpoint while the vertebrates were still confined to natural history. Morphology tended to increase in importance in both classes during the sixteen years of which we are speaking.

The first textbook of the period was Morse's "First Book of Zoölogy," published in 1875, which was a decided departure from any previously written, or, indeed, from anything which followed for many years. The author has made a selection from the animal kingdom, and begins his work with the study of mollusks "because they are most conveniently studied." This is followed by arthropods, worms and a comparative and very brief study of vertebrates. The illustrations are very different from earlier ones, in that they are done in outline, following the example of Huxley's "Crayfish." A peculiar innovation is suggested by the author in connection with these drawings; that is, that they shall be copied by the pupils in order to fix them in their minds. Other text books

of the period are Orton's "Comparative Zoölogy," published in 1876, Holder's "Elements of Zoölogy," 1884, "Text Book of Zoölogy," by Nicholson, 1885, and Packard's "First Lessons in Zoölogy," 1886. The characteristics of these books are so fully exemplified by the general characteristics of the period that it would be mere repetition to enumerate them. In addition, however, should be mentioned the increasing attention to internal anatomy which marks the treatment of the lower forms of life.

Although the text books were different in several respects from those of the earlier period the method in which they were used did not differ essentially from the earlier usage. The only important change was in the application of the theory of object lessons for the purpose of verification and to aid the memory in retaining such a mass of facts. A broader conception of the usefulness and value of zoölogy in mind training gave to its methods deeper significance and importance. It was held that in order to acquire an accurate conception of the phenomena of nature two faculties must be cultivated, i. e., memory and observation. The text carefully studied trained the one while natural objects and specimens called forth the other. The latter served to verify the statements of the former. In addition to studying the text the pupil was expected, in theory, if not in practice, to dissect and make careful drawings of his dissections. Huxley is quoted by Morse as saying that a specimen should be studied with lens and scalpel in hand. Another demand on the pupil was that he should gain a knowledge of the laws governing nature. The facts gained by the use of memory and observation were to be digested and sorted by the reflective powers and arranged in their proper relations to one another. The appreciation of the training of the reflective powers by zoölogy partially accounts for the special emphasis laid on comparative anatomy. It was not the animal as an individual which was studied, but as one of a class related in structure to other animals. With this idea in mind Packard began his book with a study of the fish in order that the students might have a standard for comparison in studying other animals. This is the most extreme and advanced idea observable during this period of comparative anatomy. The con-

tact of the pupil with nature in excursions and examination of natural objects and specimens was through the medium of the text book. Independent investigation and discovery were unknown and unadvocated in secondary work. He observed only that which he had learned from the text book he was to see and when he found it used it only as a means of verification. The inconvenience of depending upon excursions for this work was gradually outweighed by the convenience of studying specimens in the school. For the successful study of comparative anatomy dissection with suitable instruments and equipment was found to be a necessity, and out of these necessities and conveniences grew the laboratory method of the succeeding period.

(To be concluded in November.)

THE SINGING AND THE SPEAKING ARC LIGHTS.

BY K. E. GUTHE.

Assistant Professor of Physics, University of Michigan.

The interesting and striking experiments which may be performed with the singing and the speaking arcs are very little known, but require only a small number of apparatus such as can probably be found in many of the better high schools. I hope a description of some of them will prove to be of interest to the readers of SCHOOL SCIENCE.

The "singing" and the "speaking" arcs are two entirely different things. In the former, often also called the "musical" arc, noises produced by the light itself are modified in such a way as to become musical sounds; while in the "speaking," or better, "speech reproducing" arc, the arc light is made use of as a loud speaking telephone receiver.

I. THE MUSICAL OR SINGING ARC.[1]

An open arc produces hissing noises when it is too short. These sounds are probably due to the entrance of air into the crater of the arc, thus suddenly changing the electrical resistance and the current. This is followed by a variation in the volume

[1]The singing arc was first described by W. Duddell, London Electrician. Vol. 46, pp. 269 and 310, 1901.

of the incandescent vapor and thus vibrations are set up in the surrounding air which we hear as the hissing noises. In order to transform these into musical sounds we must force them to become regular vibrations.

Just as we set a tuning fork into vibrations by the irregular impulses it receives in being bowed, we may use the hissing noises of the arc as a means of starting the vibrations of an electrical resonator. Such an electrical resonator is formed by a circuit, containing capacity and self-inductance and it has a definite period of vibration, which may be written approximately, i. e., if we can neglect the electrical resistance of the wires, as

$$(1) \qquad n = \frac{1}{2\pi\sqrt{LC}},$$

where L is the coefficient of self-inductance of the circuit and C the capacity.

To form an idea of the frequency of these electrical vibrations, that is, the number of times per second the current flows into the capacity and back, we will consider the case of a condenser, having a capacity of 3 microfarads, put in series with a solenoid of double cotton covered wire, No. 21, B. & S. gauge, wound in a single layer on a cylinder, 4 cms in diameter (cross-section a=12.57 cm^2) and 40 cms long, *lsp.* There will be 416 turns of wire, N, in this solenoid.

In order to calculate the frequency n, we must reduce C and L to c. g. s. units. One microfarad equals 10^{-15} c. g. s. unit. The coefficient of self-inductance of a solenoid as described is about

$$(2) \qquad L = 4\pi a \frac{N^2}{l},$$

in our case equal to 680000 c. g. s. units. Completing the calculation for n, we obtain

$$n = 3520 \text{ vibrations per second.}$$

Putting now such a circuit consisting of a condenser and self-inductance, in parallel with an arc light, we will under favorable conditions be able to produce electrical vibrations in this system, which in its turn will react upon the arc light itself and now force the irregular disturbances to take place at the same rate,

i. e., in unison with the resonator. Probably the variations in the light consist of a rapidly alternating extinguishing and relighting. The final result is a sound corresponding to the frequency of the electrical vibrations.

In order to obtain sounds of a pitch not disagreeably high the capacity should be rather large. I obtained excellent results with a condenser having a capacity of three microfarads. The commercial condensers made by the Stanley Manufacturing Company in New York have this capacity. They are well suited for this work and cost only five dollars. With homemade condensers, consisting of tinfoil sheets, separated by paraffined paper, satisfactory results may be obtained.

If the self-inductance is too large the arc will refuse to

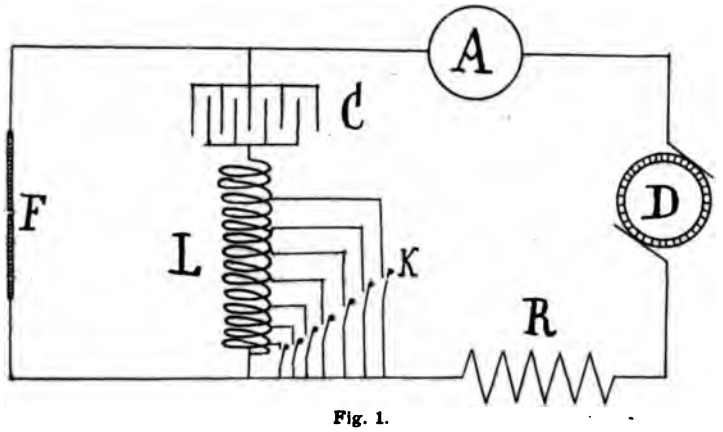


Fig. 1.

work. In the case it seems necessary to lower the pitch it is better to increase the capacity instead of the self-inductance. By varying the amount of self-inductance in the circuit tones of different pitch may be obtained and by proper selection we may construct an arc-piano on which regular tunes can be played. This can easily by done by using a uniformly wound solenoid as the self-inductance and short-circuiting parts of it by means of keys, as indicated in Fig. 1.

A short mathematical discussion will make this clearer.

Combining the above formulæ (1) and (2) we obtain

$$(3) \qquad n = \frac{1}{2\pi\sqrt{4\pi a C \frac{N^2}{l}}},$$

or by introducing $N' = \frac{N}{\epsilon}$, i. e., the number of turns per centimeter, which is a constant for a uniformly wound solenoid,

$$(4) \qquad n = \frac{1}{4\pi\sqrt{\pi a C N' \sqrt{N}}}$$

Now putting the constant factor of the expression on the right hand side equal to c, our formula reduces to

$$(5) \qquad n = \frac{c}{\sqrt{N}},$$

or, the number of vibrations per second is—with the approximation stated above—inversely proportional to the square root of the number of turns. If we select 434 turns to represent C of the tempered scale we need for the tones of the octave approximately:

C	D	E	F	G	A	B	c	
434	343	278	244	193	156	124	109	turns.

I made the final adjustment by letting the wires connecting with the separate keys form a few small turns which may be pushed together or be separated farther according as you wish the tone to be lower or higher.

The arc itself should be formed of rather small solid carbons, which are brought together by hand regulation and are then separated to a distance of only a fraction of a millimeter. For tones of higher pitch it responds more readily than to lower tones. It will be noticed that better results are obtained after the carbons have been allowed to obtain the proper shape corresponding to the very short arc.

The current for this experiment should be quite small, about 0.5 to 1.0 ampere. With our 220 volt direct-current dynamo excellent results were obtained. In general, it is better to use rather high voltage, though lower voltage—for example, our 72-volt storage battery—will suffice to show the phenomena to a large

audience. When the arc is too long, or becomes steady, the phenomenon ceases entirely.

Some striking experiments may be shown in connection with the singing arc. As explained above, the condenser is charged and discharged at a rapid rate. This current can easily be shown by inserting a low voltage lamp (4-8 volts) in the condenser circuit. It will be seen to glow brightly as soon as the arc begins to whistle, yes, even when the tones attain such a high frequency that they cannot be heard any more.

If the self-inductance is formed by a few coils of heavy copper wire surrounding a bundle of iron wire, there will be a constant reversal of magnetisation in this iron core. All the famous Elihu Thomson experiments on electromagnetic induction may be shown. For instance: Coil a rather heavy copper wire in several turns, having a diameter about that of the iron core and connect the ends by a low voltage lamp. If you hold the coil near the iron core so that the lines of magnetic force are at right angles to the plane of the copper coil, the lamp will glow, due to the current induced in the coil by the magnetic reversals. Holding the plane of the coil parallel to the lines of force, no current will be induced.

II. THE SPEAKING ARC.[1]

If we vary the current through the arc by superimposing upon it the variable currents due to the changes in resistance of a microphone when we speak into it, the arc will vibrate and reproduce the sounds falling upon the microphone. We have then a "sound reproducing," or as it is usually called, a "speaking" arc. A great number of different arrangements for the speaking arc have been proposed by various observers. I found that I could obtain very satisfactory results with the simplest possible arrangement, as shown in Fig. 2.

D is a direct current dynamo. (I suppose a storage battery able to supply the necessary current will do just as well.) *R* is a rheostat for adjusting the current, *F* the arc light. *Ch. C.*

[1]The discoverer of the speaking arc is Dr. Simon, who published the first account of it in Ann. Phys. Chem. vol. 64, p. 233, 1898; see also Phys. Ztschr. vol. 2 p. 253, 1901.

is a choking coil, i. e., a rather high self-inductance, for which I used one of the coils of a large electromagnet. Parallel to the choking coil is the circuit leading to the transmitter *T*, set up in some other room or building. Then a current due to the difference of potential at the terminals of the choking coil flows through the transmitter. A Berliner transmitter is well suited for the purpose. The difference of potential at the terminals of the choking coil should be from 6 to 8 volts.

Speaking into the transmitter will change its resistance and thus the current through its circuit. These variations are very

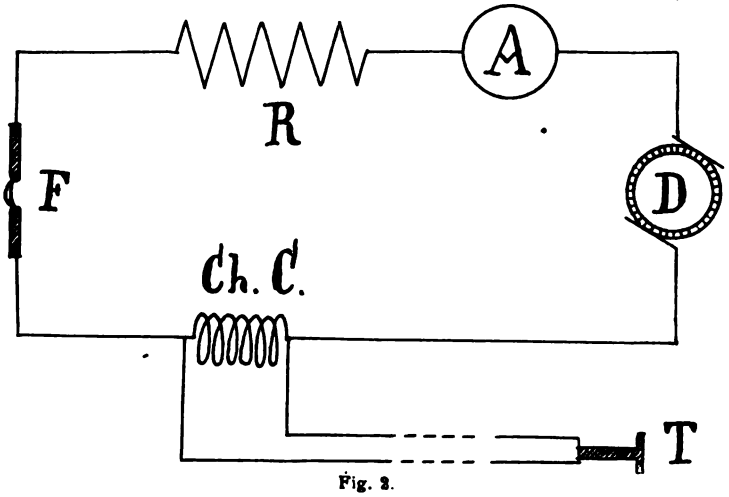


Fig. 2.

rapid, and the choking coil which offers a high resistance to rapidly varying currents will force them to pass through the arc light and the dynamo instead of short-circuiting them.

The volume of the incandescent vapor in the arc is changed and gives rise to sound vibrations in the same manner as explained in the description of the singing arc. Whatever is spoken, sung or whistled into the transmitter is reproduced with remarkable fidelity. We had no difficulty in transmitting even violin playing so that everybody in a lecture room seating over 150 people could hear every tone distinctly.

For the speaking arc a rather large current, about 15 am-

peres, is required. The arc should be very long, at least 3 centimeters. To produce a steady long arc I used large solid carbons, 1.5 cms in diameter, previously impregnated with molten sodium nitrate. This seems to have a steadying effect upon the arc. Air drafts should be avoided as much as possible, since the long arc is easily blown out.

In connection with the speaking arc, which in spite of its interesting and surprising effects must be classed with the scientific toys, it may be mentioned that attempts have been made to use it for the construction of a wireless telephone system. The light proceeding from the arc varies in intensity as the current through it varies. Let us put the arc at the focus of a concave mirror and throw the beam of light by this mirror upon another, some distance away, and there focus it upon a selenium cell. The resistance of a selenium cell is quite sensitive to changes in the intensity of light falling upon it, and it will vary at the same rate. Including this selenium cell in a circuit containing a battery and a telephone receiver, we will be able to hear in the latter the sounds which originally changed the resistance of the transmitter at the sending station. Mr. Ruhmer, of Berlin, has lately successfully established wireless telephone stations several miles apart; but, even without the rather doubtful possibility of a practical application the phenomena described belong to the most interesting discoveries recently made in the domain of physics.

A SIMPLE METHOD FOR PURIFYING MERCURY.

BY W. H. HAWKES.

Instructor of Physics, Ann Arbor (Mich.) High School.

The purification of mercury by distillation under reduced pressure or by any direct chemical process is attended by inherent difficulties that make the process unsuitable for general laboratory use. The following method will be found much simpler and less expensive: The apparatus consists of a cylindrical glass jar, say 1¼ inches in diameter and 8 inches deep, to which is

fitted a double perforated stopper, preferably of rubber, through which pass two glass tubes, one reaching nearly to the bottom of the cylinder, the upper end extending about one inch above the stopper. The other tube is bent at right angles, the lower end reaching about ½ inch below the stopper, while the upper end is connected by means of a rubber tube to a Chapman aspirator. An electric light carbon free from copper on its surface and of such a length as to reach from the bottom of the jar nearly to the stopper completes the outfit.

Fill the jar about half full of the mercury to be cleaned, pour on the mercury to the depth of about an inch dilute sulphuric acid (parts about one to ten). Introduce the carbon and insert the stopper, shake, gently rocking the mercury back and forth through the acid; this accelerates the action to take place by bringing the acid in contact with the entire mass of mercury. Now connect the aspirator, using a rubber tube, with the water faucet, and turn on the water until air bubbles up freely through the mercury. Electrolytic action between the impurities of the mercury and the carbon at once sets up in the presence of the acid, the salts produced going into solution. Allow the action to continue for about a half hour, then pour off the acid solution and add fresh acid; continue the action for a half hour longer; mercury badly contaminated may require a longer treatment.

The mercury may now be washed and dried in the following manner: Pour off as much of the acid as can be safely done and not spill the mercury. Introduce clean water, repeatedly, until the last washing gives no reaction for acid. A large, well stoppered bottle may be used for this, so that water and mercury may be shaken together. When sufficiently washed pour off as much water as possible and not spill the mercury. A pipette or siphon may be of use in removing water from the surface. Strips of clean batting paper, or folded filter paper thrust down into the mercury will further dry it. Now filter through filter paper, perforated at the point of the fold; fine perforations are needed so that the mercury passes through slowly, and the process is complete.

Impurities of an oily nature may be removed by washing in potassium hydrate and then in clean water, drying and filtering as above described.

It has been found that mercury contaminated with sulphur from rubber tubing and with zinc lead and copper from ordinary use in a laboratory can be cleaned quite effectively and with little or no loss of mercury by the process as given. Any form of aspirator may be used, as long as a considerable quantity of air is driven through the mercury.

The office of the air is a double one. It appears to remove some of the impurities by oxidation, as may be shown by going through the operation leaving out the acid. It also brings the acid by constant agitation in contact with all parts of the mercury.

POLARIZATION OF A GALVANIC CELL.

BY ARTHUR W. GRAY.

The directions given in most elementary text books on physics convey the impression that it is the simplest thing in the world to show satisfactorily the counter electro-motive force of polarization in a simple galvanic cell. And so it is if conditions are just right; but most of the directions give no hint as to the right conditions. Again, the experiment usually employed to illustrate this phenomenon shows merely that the current rapidly weakens after the circuit is made, whereas it is very easy to show in addition that this weakening is due to the presence of the gas bubbles on the copper plate, and also that these bubbles cause a counter electro-motive force, as well as an increase in resistance. When these points are clearly brought home to the pupil's mind by convincing experimental evidence, he has very little difficulty in understanding the essential action of depolarizers.

In arranging an experiment for this purpose attention should be given to the selection of a suitable galvanometer, and to the controlling of the rapidity of polarization, so that it will

take place slowly enough to be followed without difficulty. A very effective galvanometer can be constructed by wrapping ten or fifteen meters of number thirty copper magnet wire around an ordinary pocket compass having a needle about three centimeters long. A convenient mounting for this can be made by gluing back to back two pasteboard trays, each about four centimeters square and one centimeter deep. The compass should be placed in one of the trays, and the winding guided by slits cut in the sides of the other. By having a large resistance in the circuit, the action can be controlled so as to take place slowly. This resistance is most conveniently obtained by using for the galvanic cell a tumbler filled with clean water, to which has been added one or two drops of concentrated sulphuric acid. Troublesome vibrations of the needle will be avoided if the circuit is completed by immersing the copper plate, corner first, and lowering it gradually as the needle deflects. Before immersion this plate should be dry, and freshly cleaned by scouring with emery cloth.

In a minute or so an original deflection of about 45° will be reduced to 20° or less. If the gas bubbles be now brushed off the copper plate by vigorously agitating the liquid in front of it with a rubber-tipped stirring-rod, the deflection can be increased to 35 ° or more, quickly returning to about 20° when the stirring is stopped. Gently flowing a strong solution of copper sulphate over the gas-coated copper plate will destroy the bubbles and restore the deflection to about 45°. A solution of chromic acid will increase it to about 70°. Before each trial it is advisable to clean and brighten the copper plate by thoroughly scouring with emery, and to fill the cell with a fresh solution of sulphuric acid.

The strengthening of the current upon the removal of the gas bubbles shows merely that the weakening is due to their presence. If the pupils have been properly prepared they will see that the bubbles might weaken the current by introducing resistance, by causing an opposing electro-motive force, or by a combination of both. To show the presence of the counter electromotive force two copper plates are needed. After it is seen that under ordinary conditions no current passes when the cell is

set up with two like plates, it should be set up as before with a zinc plate and a copper plate, and the current should be allowed to run until the latter has become well coated with bubbles. If the zinc plate be then removed and replaced by a clean copper one as soon as the galvanometer needle comes to rest at zero, a considerable deflection in the opposite direction will be obtained, which will gradually fall back to zero again as the bubbles disappear.

This experiment has uniformly given very good results even in the hands of mediocre pupils.

If it be desired to show that the gas bubbles are hydrogen they can be collected by having the copper plate bent into suitable shape and held under an inverted test-tube of dilute acid. Of course, the cell solution for this purpose should be strong enough to generate the gas rapidly, so that an unreasonable length of time will not be consumed in collecting sufficient for a test.

I might add that a convenient shape for plates to use in a simple tumbler cell can be made by bending over to form a J-shaped hook one or two centimeters of a strip of metal about three by ten centimeters. A close coil about one centimeter in diameter formed of four or five turns of number fourteen hard-drawn brass wire soldered to the bent-over portion of the plate answers all the purposes of a binding-post. When plates of this design are hung from the edge of the tumbler, they are held firmly against the sides of the latter, so that there is no danger of their touching each other.

LABORATORY MATERIAL FOR GENERAL BIOLOGY.

BY A. J. GROUT,
Instructor in Biology, Boys' High School, Brook'yn, N. Y.

I have used Parker's Biology as a textbook in general biology for several years, and in striving to provide several hundred boys with laboratory material to accompany that admirable textbook I have devised or plagiarized several schemes that may not be known to all teachers of biology and which will certainly be useful to the younger and more inexperienced teachers. For the last two or three years I have had amœba so abundantly that each one of three hundred boys could have a specimen all to himself.

For amœba, vorticella and paramœcium I proceed as follows: I take a large valise full of quart fruit jars and a pair of rubber boots and go to a sluggish stream or pond where water plants are abundant and the mud rich and dark. I scrape the surface mud from the bottom of the stream, or better, from stones that can be lifted out of the water; I pull up the weeds and strip them through my fingers, letting the attached material drip into my jars. In this manner I fill six or more jars, which I take to my laboratory and empty into convenient receptacles. I pick out any surplus of vegetable matter, always leaving sufficient to keep the mixture good and rich by its decay. I then add water, and from time to time supply enough water to prevent drying up. In about two weeks I begin to search for amœbæ, which I usually find in abundance in some dishes, while not a solitary one can be found in others. Unless one knows how and where to look for them, he may have a million amœbæ and yet have difficulty in getting one. If your culture is just right the amœbæ, which were so scarce as to be practically indiscernible at first, will multiply to such an extent in two or three weeks that you can take up dozens with one sip of the pipette, if you choose the right spot. The surface of the sediment at the bottom of the dish is always a good

hunting ground, but my best results have come from scraping off a little of the ooze which collects on the edge of the dish just below the water line. Here minute algæ thrive and here amœbæ swarm to devour them. By tipping the dish slightly a little of this ooze can be scraped off on the point of a knife and readily transferred to slides.

There are many other methods of obtaining amœbæ. One of my fellow teachers, for instance, has obtained them in abundance from the underside of a decaying "lily-pad." But the safest and surest way is to make a culture in the manner outlined. I have found the Bronx river the best hunting ground for amœbæ and many other infusoria.

Sooner or later *paramoecium caudatum* will appear in quantities in some of my mud cultures, but after a week or two they diminish rapidly in numbers and soon will entirely disappear unless a bit of lean meat (beef) be placed in the culture, when they will develop in such numbers as to make the water whitish around the decaying flesh. (See later account.)

In making cultures for amœba and paramœcium I always leave some bits of grass or other vegetable matter, and after a week or two I am always sure to find vorticella attached to some of this vegetable debris. They can also be found attached to the sides of the containing vessel, but they can be much more satisfactorily studied if mounted together with their attachment. The related colonial forms are often met with, but are much less satisfactory for class work, because they disintegrate under the cover glass in a very short time.

Hæmatococcus, or more accurately *sphaerella pluvialis,* is easily obtained in quantities sufficient for any number of students by obtaining rock fragments from the pools in which they naturally occur. My material has always come from some pools in ledges near Burlington, Vt. I understand that several of the firms that supply botanical material for laboratory classes will supply this material. When the pools dry up, the resting stages of sphærella form a reddish-brown crust on the bottom of the pools and on any objects in them. If pieces of stone covered with this crust be placed in a glass dish of water in a moderately warm and light

place (not bright sunlight) in a day or two the water will swarm with the motile stages and will form a red line at the surface on the side nearest the light. They can easily be transferred to a slide with a pipette. They are so minute that I find it very advantageous to mount with a few fibers of cotton, which serve as a guide to focusing, prevent the slide from drying out too suddenly, and in some degree hinder the too active movements of the spirella. If a small quantity only of material be desired it is better to scrape a little of the crust into a small beaker of water. By so doing the same piece of rock may answer for several years.

The method for obtaining fresh-water hydra recommended by the textbooks, i. e., placing some water weeds in a saucer and removing the hydra individually with a pipette, is ridiculous. I collect several quart jars almost solid full of duckweed from the surface of some convenient ditch or pool. The free, unentangled plants are much the best. Enough water to thoroughly cover is placed in each jar. The jars are carried, as soon as possible, to the laboratory and emptied into glass jars holding from two quarts to two gallons and the jars filled up with water. The next day the hydra will be found clinging in great numbers to the sides of the dish, if the catch is a good one. I then remove most of the duckweed and partially change the water. Great care has to be taken to remove all the organic matter except a few plants of duckweed, for any appreciable decay will kill the hydra very rapidly. On the second day I usually entirely change the water by pouring it off, as the hydra will cling to the sides of the vessel. The hydra will perish in the closed collecting jars in a few hours, and must be removed as soon as possible, if they are to remain healthy. The hydra will live for a long time without feeding if other conditions are favorable, but a whole aquarium full will sometimes suddenly vanish as if by magic. If the animals be distributed in small receptacles, like fruit jars or ordinary drinking glasses, this wholesale disaster may be avoided.

A friend often collects large quantities of *hydra fusca* by picking up sticks and stones at the bottom of a clear, moderately swift brook and then putting in fruit jars and treating precisely as outlined above for the treatment of the hydra on duckweed.

A small stone the size of one's fist will sometimes have hundreds of individuals attached to it.

Oscillaria I find readily in slow-flowing streams contaminated with sewage.

Vaucheria can be found in winter and early spring in almost any greenhouse and can be made to produce sexual organs by washing clean and putting in clear water. Organic matter in the water sufficient to cause decay will be fatal. In the greenhouses also one can usually find an abundance of fern prothallia and various stages of development of the mosses.

ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY

BY GEORGE W. MYERS.

(*Continued from page 173.*)

If a star has a parallax of one second, it is then 206,265 times 93,000,000 miles from the eye; if the parallax is 0″.8 the star's distance is $\frac{206{,}265 \times 93{,}000{,}000}{0''.8}$ and, in general, if the star's parallax is denoted by p'' and its distance in miles by D, we have

$$D = \frac{206{,}265 \times 93{,}000{,}000}{p''}$$

For most stars p'' is small, and D is so large a number that a longer unit than the mile is preferable. The ordinary unit is the *light-year,* which is the distance that light travels in one year at the rate of 186,000 miles (=300,000 kilometers) per second.

Find the distance in miles and light-years to the stars tabulated here from the parallaxes placed beside them:

*For the convenience of those who may desire to use these experiments (there are forty-four of them) in their classes, they may be obtained in pamphlet form from "The School Science Press," Ravenswood, Chicago, at 25 cents a copy, and $2.50 a dozen.

	Star.	Parallax.
1.	α Centauri	0″.75
2.	61 Cygni	.40
3.	Procyon	
4.	70 Ophiuchi	.25
5.	Vega	.16
6.	Polaris	.074

Prove that $D = \frac{3.26}{p''}$ gives the distance to any star in light-years, p'' being the parallax of the star in seconds, and D the distance from it to the earth, or sun, in light-years.

Experiment XXXVIII.

To find distance from earth to sun by geometrical methods connected with transit of Venus observations.

(a) *Observers are displaced in longitude.*

Let S, V, and E denote the sun, Venus, and the earth, respectively.

When Venus is in line with the earth and sun, and between them, she is said to be in *inferior conjunction;* when in line, but beyond the sun, she is in *superior conjunction.* Observation shows that Venus requires 584 days to pass from either conjunction to the same conjunction again. This is the same as saying that it requires Venus 584 days to gain a complete revolution, or 360° on the earth. The daily gain is accordingly ....° = 37′ (nearly); or 1′ 32″.5 per hour.

Two observers at stations A and B as far separated in longitude as possible on the earth; note the instant when Venus touches the solar disk. Of course, the easternmost observer at $A1$ sees the beginning of the transit first. Venus moves onward in her orbit to $V2$, when the western observer sees the first contact of Venus with the sun's disk. Evidently Venus, in the meanwhile, has gained the angle $A2\,D\,B2$ on the earth. If an observer were at D, this is the angle under which the chord $A2\,B2$ of the earth would be seen by him. If the observers at A and B are 6,000 miles apart in a straight line (and a former experiment has taught us how to compute this distance), and the angle is

found to be 13″.2, since any magnitude must be 15,500 times its own dimension from the observer to open up 13″.2 at his eye (Experiment IV.), the distance to the sun $D\,A$ (or $D\,B$) equals 15,500×6,000=93,000,000 miles. This exercise may be studied

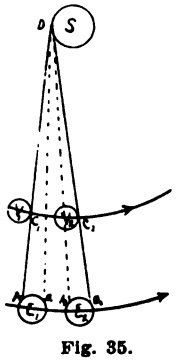


Fig. 35.

concretely by cutting out three wooden disks and attaching strings by light staples, carpet-tacks, or pins, as the lines are drawn in the cut.

Using the data of any table of planetary elements and substituting in the problem, work through and check the value of the distance from the earth to the sun.

(b) *Observers displaced in latitude.*

To obtain as long a base line as possible one observer should select a station as B in as high northern latitude as possible, and

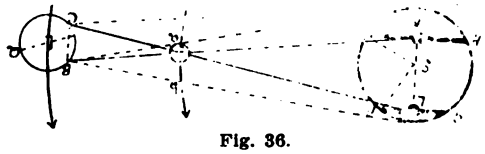


Fig. 36.

the other at C in as high southern latitude as possible. ($E\,Q$ denotes equator.)

To an observer at the northern station, B, at the time of a transit, Venus will be seen projecting on the disk of the sun, while she is crossing a cone whose vertex is at the observer, B,

and whose centers are tangent to the sun's surface. Experiment XXX. will show that Venus is at 0.72 of the earth's distance from the sun, so that the one where Venus crosses it is only 0.23 of the solar diameter. The line at, seen from S is 32′ 04″ on the average, when the transit is central. Seen from S, the line ab would then have the angular magnitude 1.38 × 32′ 04″ = 101′ 14″.6. (See under "a".) The hourly gain of Venus on the earth is 1° 32′.5 on the average, and the duration of a transit of Venus, which is central, is then 6.64 hours. The duration of other transits will sustain such a ratio to 6.64 hours as the lengths of the chords of the solar disks traced by Venus' projection on the sun during transit sustain to the angular solar diameter 32′ 04″.

This latter diameter is directly measurable in terms of angular units, and the chords traversed by the projection of Venus are readily computed from it.

If then viewed from *C* in high south latitude, Venus seems to describe a path such as *FG*, and from *B* a path such as *DH*, computing the times of transit with 6.64 hours, we find the ratio to 32′ 04″ of the lengths of these arcs in angular value (*SD* and *SF* being 16′ 02″). *SK* and *SL* are readily found by the Pythagorean Proposition.

[Note: *GF* is to *2SD* as the time of transit along *GF* is to 6.64 hours.]

Angles *BVC* and *DVF* being equal, and *BC* and *LK*, or *FD* being supposed parallel, we have the triangles *BVC* and *FVD* similar; hence:

$$\frac{FD}{BC} = \frac{VB}{VS} = \frac{7}{10}, \text{ or } FD = 0.35\ BC.$$

The observers *B* and *C* know their latitudes and longitudes and compute the length of *BC*. The line *FD* then becomes known in miles. Knowing, then, the length of *FD* in both degrees and miles, we compute, then, how many degrees and miles there are in *LK* and how many miles in *SD*, and we then have how many seconds one mile or 4,000 miles correspond to when seen over the distance from earth to sun. It is found that 4,000 miles viewed from the earth-sun distance would subtend an angle

at the eye of 8″.8. But experiment V. would show us that to make any magnitude open up 8″.8 at the eye it must be placed 23,250 × its own length from the observer. Hence the distance to the sun is 23,250×4,000 miles (roughly)=93,000,000 miles.

Cut out two circular wooden disks such as *BQC* and *FGHD*, and fasten two strings with staples, one at *B* and *D* and the other at *C* and *F*. Running the strings through a bead at *V*, the problem may be made to stand out before the eye concretely. Globes will be better than disks if they are available.

THE PRECESSIONAL GLOBE.

Description: *P*. The north pole of the heavens. *Q*. The

Precessional Globe.

Fig. 37.

north ecliptic pole. *R*. Brass circle with center at pole of ecliptic, radius, 23½°. *M*. Meridian graduated to degrees. *S*. Scale graduated on one edge to miles and on other to degrees. *T*. Thumb-screw to carry and clamp *S* along meridian. *H*. Wooden horizon, graduated. *E*. Equator. *C*. Ecliptic, and *D*, sliding support to *M*.

The circle R is perforated with 26 equally spaced holes, extending entirely around it, and around the south ecliptic pole is

another precisely similar circle. At P is a pin, held in place by a spring, which may be set in any one of the twenty-six holes, a similar pin being first set in the diametrically opposite hole of the south pole circle.

Since the precessional motion carries the poles of the heavens around these circles once in 26,000 years, the spaces between adjacent holes corresponds to the motion of the poles during 1,000 years. It is therefore possible to bring the globe into such positions as to represent the aspect of the celestial motions about the instantaneous pole positions for any integral number of thousands of years of the past or future. The positions of the poles for *any* epoch may be represented on this globe, while on an ordinary globe they can be represented for only a *single* epoch. The following important astronomical facts may be visualized by proper settings of the globe:

1. The revolution of the First of Aries through the signs of the zodiac.
2. The revolution of the celestial pole about the ecliptic pole.
3. Changes in the right ascensions and declinations of the stars.
4. Changes in the longitudes of the stars, but not in their latitudes.
5. The tropical year is shorter than the siderial year.

Exercises to be solved with the precessional globe.

Experiment XXXIX.

To determine the Polestar at any given epoch.

(a) What star was nearest the north celestial pole when the great pyramid of Cheops was built 6,000 (?) years ago?

(b) What star was nearest 1400 years ago? 1400 B. C.? 8500 B. C.? 14000 B. C.?

(c) When will Vega be the Polestar?

(To be concluded in November.)

NOTES ON THE PROGRESS OF CHEMISTRY.—I.

BY LYMAN C. NEWELL, PH. D.

It is the purpose of SCHOOL SCIENCE to publish at intervals notes on the progress of the chemistry which is of special interest and service to teachers. No attempt will be made to cover the field nor to reproduce whole articles. But we trust that the matter selected will meet the wishes and needs of busy teachers.

Chili Saltpeter. By Emory R. Johnson, Jour. of Geog., February, 1902, page 55.—Part of an account of the industries of South America. The salt "lies in a nearly continuous deposit parallel to the seacoast, extending 150 miles from north to south, with scattering deposits reaching 250 miles farther, the total covering 220,356 acres, and estimated to contain about 228,000,000 long tons. The nitrate is found under the surface layer of sand, and when shoveled out has the consistency of cheese. It is refined in numerous plants requiring large capital. The crude product is dissolved, chemically treated, and crystallized to remove the impurities. Among these impurities are compounds of iodine and common salt."

The Molecular Weight of Sulphur. By Charles F. Lindsay, Amer. Chem. Jour., March, 1902, page 220.—A review of the recent work on this problem. "It has been shown that at the lowest temperatures at which sulphur can be vaporized it exists as S_8. As the temperature rises, this commences to break down into the molecules S_2, while at temperatures above 900 degrees sulphur exists solely as S_2. In solutions it exists as S_4."

Solid Carbonic Acid from "Sparklets." By R. W. Wood, Sci. Amer., March, 22, 1902, page 203.—Remove the top of the siphon bottle, insert the cooled "sparklet" capsule, tie tightly over the (inner) end of the tube a piece of black velvet so that a small bag is formed, screw down the cap, and the gas which escapes into the bag will solidify. A drop of mercury may be frozen in a few seconds by the solid carbon dioxide.

Preparation of Tantalum in the Electric Furnace. Sci. Amer., April 5, 1902, page 236.—Detailed account of the preparation and properties of pure tantalum. Potassium fluotantalate treated with sulphuric acid yields tantalic acid. The latter mixed with sugar charcoal and heated in a graphite crucible for ten minutes with a current of 800 volts and 60 amperes yields the metal in a fused state. The cooled metal has a brilliant luster and crystalline fracture. It will scratch quartz, is infusible in the oxy-hydrogen blowpipe flame, insoluble in *aqua regia*, soluble in nitro-hydrofluoric acid. Its density is 12.79. It is attacked by fluorine at

the ordinary temperature, by chlorine at 150 degrees C. and vigorously at 250 degrees C., oxygen at 600 degrees C., by gaseous hydrochloric acid, by ammonia gas, not by iodine (at 600 degrees C.), nitrogen, phosphorus, arsenic, and antimony. It reduces sulphurous acid and lead oxide.

Sulphuric Acid and Its Preparation by the Contact Method. By J. Elliot Gilpin, Amer. Chem. Jour., March, 1902, page 227; *Sulphuric Acid and Its Manufacture by the Contact Process.* By R. Kneitsch. Translated by Jas. L. Howe. Pop. Sci. Mo., May, 1902, page 24.—The first article is a technical account of this process and the second is a popular translation of a general non-technical lecture on the same subject. A brief account is also publishe din the Pop. Sci. Mo., March, 1902, page 479. We quote from this article: "Theoretically the process is a model of simplicity. The gases from the pyrites burners, consisting chiefly of sulphur dioxide, oxygen and nitrogen from the air used, are, after purification and cooling, led through cylinders containing plates on which a contact mixture, with platinum as one of its constituents, is placed. The sulphur dioxide burns with the oxygen present in the gas, giving the trioxide, which is absorbed in a dilute acid. The acid obtained may be pure sulphuric acid, or may contain an excess of the trioxide—the fuming or Nordhausen acid. Several years of most patient investigation were, however, required before the conditions were discovered by which the process could be kept in continuous operation, there being a great tendency for the platinum mixture to cease its work after a few days' or even hours' use. This was due to the presence of impurities in the gas from the burners and especially to arsenic. The slightest trace of this element at once inhibits the action of the platinum." This method furnishes a strong acid free from arsenic.

The Liquefaction of Hydrogen. By F. H. Getman, Pop. Sci. News, June, 1902, page 135.—A resumé of the various attempts to liquefy hydrogen, special stress being laid upon Dewar's work. Accurate, complete, interesting. Illustrated by three figures.

Some Recent Work on Hydrogen Dioxide. By F. H. Getman, Pop. Sci. News, May, 1902, page 111.—Review of the work of Bredig and Calvert, proving that hydrogen dioxide has weak acid properties. Five methods were used. (1) When a substance divides itself between two solvents, the ratio of the concentration in each remains constant, provided the solute has the same molecular aggregation in each. Water and amyl alcohol gave the partition coefficient 7.03. Addition of sodium hydroxide changed this constant, showing the formation of a compound—a salt consisting of one molecule of sodium hydroxide and one and a half molecules of hydrogen dioxide. (2) The freezing point of $\frac{N}{4}$ sodium hydroxide solution was not lowered by adding $\frac{N}{6}$ hydrogen dioxide—a

salt having been formed. (3) The retardation of the saponification of ethyl acetate by sodium hydroxide was found to be proportional to the amount of hydrogen dioxide present—thus proving the removal of sodium hydroxide from the field of action by the hydrogen dioxide. (4) The conductivity of sodium hydroxide is diminished by the addition of hydrogen dioxide—the latter acting like a weak acid. (5) Hydrogen dioxide moves as an anion (this proof needs the figures and data of the article).

A Dry Salt Sea in the Desert. By Arthur Inkersley, World's Work, May, 1902, page 2105.—Illustrated description of the field of crystallized salt at Salton, California, in the Colorado desert, a little north of the Mexican border line. The deposit is 264 feet below sea level, and covers a thousand acres. The salt is supplied by springs from adjacent hills. The crust left by evaporation is almost pure salt from ten to twenty inches thick. A massive plough throws up the salt into furrows. It is then hoed in salt water to remove earthy matter, stacked in conical mounds to drain, and later removed to the mill. Here it is ground, sifted, and packed in sacks for shipment. The quality is good, but much is sold unrefined as "hide salt." The laborers are Indians and Japanese, because no white man could endure the heat (140 degrees F.), the reflection of the sun and the painful thirst. The supply of salt seems inexhaustible.

Ammonium. Science, March 14, 1902, page 434.—An exhaustive series of experiments by Moissan failed to give any evidence of the existence of the radical, ammonium. His work included the electrolysis of ammonium chloride and ammonium iodide in solution in liquid ammonia, the examination of ammonium amalgam when in a perfectly stable condition, and the action of liquid hydrogen sulphide on lithium-ammonium and calcium-ammonium at —75 degrees. He believes that under some circumstances ammonium hydride, N H_4 H, exists.

See, also, On the Existence of Ammonium, Amer. Chem. Jour., Jan., 1902, page 77, and Metal-Ammoniums, Ibid., June, 1902, page 489. The latter is an accurate review of Moissan's work above mentioned.

Radio-Activity. By Robert K. Duncan, Harper's, August, 1902, page 357.—Popular article on the discovery of this new property of matter. Includes an account of the discovery of radium. Illustrated by thirteen figures and also by portraits of Becquerel and the Curies. "Radium has never been isolated. We know that it exists as an element solely and completely through the fact that every element has its own sign manual or spectrum. The lines [in the spectrum of radium] are caused by no other known element on the earth or in the heavens. Therefore radium is a new element." The spectrum was obtained from a minute quantity of pure radium chloride.

Metrology.

HOW UNCLE SAM GOT A DECIMAL COINAGE.

BY DR. WILLIAM H. SEAMAN.

About a year ago a small party interested in the metric system of weights and measures discussed the apparent anomaly of the United States adopting a decimal currency while adhering to the old English weights and measures. None of the party could give the history of the matter, and inquiry developed the fact that but few knew of any direct source of information, so the writer concluded that a summary of the result of inquiries on the subject would interest other people. The use of silver and gold as money antedates written history. These metals have always been the preferred money of the people most advanced in civilization, but very many other substances have been used for various reasons. In Tartary people used cubes of pressed tea, in Rome and Germany cattle, in the West Indies sugar, in Mexico soap, in Campeachy logwood, in Abyssinia salt, in Africa cowrie shells (also in Asia) and in America wampum. Rome had money of leather and of wood, Virginia used tobacco and slaves, Newfoundland cod fish, Syracuse an ancient Britain tin, Sparta iron, Burmah lead, Russia platinum, China silk, Scotland nails; all modern nations have made believe paper was money, and furs and skins were in common use in the early history of this country. In 1636 the Colonial Assembly of Massachusetts allowed the towns to pay their taxes in corn, and about the same time also declared that "Musket balls of a full boare should pass currently for a farthing apiece, provided that noe man be compelled to take above 12 pence at a tyme of them." The first use of metal as money appears to have arisen from the payment of taxes or contributions to those in authority in pieces of metal which were then stamped with their weight and fineness and paid out again as is now done

*Communications for the Department of Metrology should be sent to Rufus P Williams, Cambridge, Mass.

in an assay office. The making of pieces of uniform size, shape and quality came much later. The early money was made by setting a die in a block of wood, forming a small ball of the metal and placing it on the die, then setting a punch on the metal and striking the punch with a sledge. Later a ring was put round the die, and the face of the punch was likewise engraved. A screw press was first used by Antonie Brucher in France in 1553, but it cost more than the punch, and in both France and England was given up for awhile.

All the world was at first on a silver basis. Abraham bought a tomb for Sarah with "four hundred shekels of silver" 1,859 years before Christ. A hundred and thirty years afterward Joseph was sold for twenty pieces of silver. The phrase "pieces of silver" probably refers back to the time when the pieces were not all the same size—in a word, when the metal was a commodity, and a convenient measure of value, but not a coin. The earliest existing coin is the Lydian states—an alloy of gold and silver, made about 700 years before Christ. The making of coins was not limited to the larger governments, but, during the Grecian history, every city made its own coins, and at the same time a great deal of foreign money was in circulation in Greece. A similar condition of things prevailed during the middle ages in Europe. The great merchants, the Fuggers, struck 80,000 gold gulden in their private mint at one time to pay a fine levied on their native city by the Emperor, Charles V.

Partly by hoarding, caused by the insecurity of property, and partly by the demands of the new-found commerce with the East at the time of the discovery of America the quantity of precious metals in Europe in actual use had somewhat diminished. At this time the relative value and use of gold had increased, but the flood of silver, poured into Europe by the Spanish colonies in America, made it the most important metal for commercial purposes. It is curious to note that the entire history of the invention of money among the earliest of the human race was repeated by the Spanish conquerors of New Spain. In Peru, at the time of the Spanish conquest, copper was more valuable than gold. The coming of Europeans soon changed their relative value to

the standard of Europe. All precious metals paid one-fifth to the King of Spain, and they were then cast into bars, or the gold was sealed up in little bags with the royal seal, having their weight, fineness and value in Spanish coin marked on them, just as somewhat similar practices marked the beginnings of California and Australian gold digging. Meantime Spain was not slow to perceive that she held the control of the world's supply of the precious metals, and it became her study to endeavor to secure for her government as much of the product as possible. She forbade the exportation from Spain of coin, in order to exact a heavy tax, above one-fifth, on stamping the metals got in the colonies, and when the colonists tried to avoid this impost by weighing out the crude metal they were forbidden to do so till it had been stamped. In addition, the king made numerous arbitrary changes in the value of his coins and in the relative values of gold and silver. The king's dues must be paid in coins of full weight, the public expenses were met with clipped coins. Numerous counterfeits made their appearance, due bills made of leather circulated in 1586 in San Domingo and Porto Rico. The first mints were established in 1535, but the exactions for coining bullion into money soon became so great that in three years the colonists refused to bring bullion to the mint. They were allowed to coin only silver. It was not till 1589 that gold and copper could be minted in America. The American viceroys had used many different weights and measures, but by the decree of 1581 these were all superseded by the weights and measures of New Castile, and in 1608 the cost of coinage was lessened and the amount made practically unlimited. This act did not take full effect till England, in 1666, reduced her charges for coinage to a reasonable figure, and the ease with which silver could be surreptitiously taken over to Britain destroyed the monopoly of Spain in silver money. An enormous variety of coins was in use in Europe at this time, many of which were brought over to this country by the emigrants. The money of account in Spain was reals and maravedis, but she had a dozen different kinds of coins, of which the value varied almost from year to year, according to the whims of her rulers. Among them was a piezas d'ocho, or piece of eight, so called be-

cause it was worth eight reals. The phrase piezas d'ocho seems gradually to have been contracted to piezas alone, then to pesos or peso, and in this form it survives today. Among the private mints of the middle ages was that of Count Schlick, 1517-23, in a valley known as Joachims Thal, Bohemia, and as the plural of that is thäler, the pieces they coined became known as Joachimsthäler, and finally simply thälern. They were maintained of the same value, about one ounce of silver, and hence became an acceptable currency over central Europe, and the name has been adopted for their principal coins by Sweden, Norway, Denmark and the United States. This coin and the Spanish peso were substantially identical; in fact, the Spaniards sometimes used the word dalera in place of peso, and the mints of both Spain and Mexico turned out large quantities of these pieces. The early colonists found a most profitable commerce in sending their grain, fish and rum to the Spanish settlements in the West Indies and the Spanish main, and in bringing back Spanish milled dollars, and thus this coin became more general than any other throughout the colonies long before the Revolution.

The advocates of a change in our weights and measures are often met with an apparent belief in the fixity of such matters, as if the present conditions had always existed, and therefore should not be disturbed. A very little acquaintance with the history of the subject will dissipate any such ideas; we have changed and are changing them, and the main question is whether the changes shall be made according to a carefully selected and settled plan, or whether they shall be left to chance, as hitherto.

In the early days of the present writer Mexican shillings and sixpences were universally current in the city of New York and farther south. My father was quite able to calculate in pounds, shilling and pence, a kind of arithmetic that was far from simple, since the Irish pound was as twelve to thirteen of the English pound, and 100 New England pounds were worth 75 English pounds, while 100 New York pounds were worth £56 5s and 100 New Jersey £60, and livres, piastres, Johannes, Joes and half Joes were common as shillings, and when it comes to measures, who of the present generation will recognize this table

from an old arithmetic, especially if recited in sing-song style common for recitations then:

Four pecks	make	one bushel,	7 pounds	make	one clove,
Two bushels	do.	one strike,	2 cloves	do.	do. stone,
Two strikes	do.	one coom,	2 stones	do.	do. tod,
Two cooms	do.	one quarter,	6½ tods	do.	do. wey,
Four quarters	do.	one chaldron,	2 weys	do.	do. sack,
Five quarters	do.	one wey,	12 sacks	do.	do. load.
Two weys	make	one last,			

Such were the tables in Dilworth's arithmetic in 1789.

(To be continued.)

NOTES.

Colonial Premiers Recommend Metric System.—The Colonial Congress, held in London, England, at its final session, August 11, passed a resolution favoring the adoption of metric weights and measures throughout the British Empire. Though this makes nothing mandatory, and exclusive use of these measures must depend upon legislative action in each colony, the act of the Colonial Premiers is of far reaching influence. The resolution, with others, was in the interest of trade, and it is believed that colonial parliaments will not long refuse legislative aid to increase foreign commerce and improve conditions at home. The various resolutions will soon be issued in a parliamentary paper, and a metric bill, we are informed, will be introduced in the House of Commons or House of Lords.

In the Textile Industry.—At the February meeting of the Board of Trustees it was voted to make the metric system the standard system of weights and measures for the Lowell, Mass., Textile School. The importance of this act can hardly be overestimated in the textile industry, as the school is one of the largest and probably has the most varied equipment of any similar school in the world. Its trustees and incorporators are manufacturers and practical business men, representing a capital of over $65,000,000.

Another indication is that in March the Secretary of State of India, in response to many urgent requests, wrote the British Association of Chambers of Commerce to get the consent of manufacturers to use the metric method of count. One letter states: "The Indian dealers have got so accustomed to the Continental [metric] count of worsted wool yarn that they absolutely decline to give orders for yarn made up according to the British standard of count, and stipulate, when giving orders, that the yarn must be made up according to the system in vogue on the Continent." Other letters were of similar import. The Chambers of Commerce replied that they "approve the metric system of notation for woollen and silk yarn exported to that country."

R. P. W.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of great value.

BOTANY.

NOTES ON THE STUDY OF SEEDS.

1. To furnish opportunity for observing those features of plant growth which cannot be seen above ground, the following simple plan has been used. A glass tumbler containing moist sawdust was given each student. In this were planted seeds which were placed against the glass with the micropyle pointing outward. Thus the early development of the embryo was followed and in a little while material was at hand for the study of roots and root-hairs. A larger and better arrangement for illustrating the same thing is described in Ganong's Teaching Botanist. In performing experiments to show the relation of moisture and temperature to germination, I have also found this device convenient, that is, to plant seeds against the side of the tumbler where the number that germinate under the varying conditions of moisture and temperature can be noted.

2. In order to see to what extent seeds are able to withstand the low temperature of our New England winters, the members of the class have collected and planted seeds that had weathered the winter and were found still clinging to the plants that bore them. An account has been kept of the number of each kind planted, and the number that germinate will also be observed.

3. While studying seed-locomotion, a beaker filled with water was given each student, who experimented to learn what seeds would float after being left in water for a little time. It was found that quite a number which had special appendages for distribution by wind or animals were undoubtedly able to take advantage also of running water. One interesting case in particular was the seed of the milkweed. The little rim around the seed was found to serve a double purpose, not only to aid in distribution by wind, but by water as well, for while the seed ordinarily floats, it sinks when the rim is removed.

GILBERT H. TRAFTON.

Book Reviews.

Outlines of Botany for the High-School Laboratory and Class Room. Based on Gray's Lessons in Botany—By R. G. LEAVITT, A. M., of the Ames Botanical Laboratory. 13½x21½ cm. The American Book Company.

Teachers who have found so many good points in Gray's Botanies and have used his text in the high school will welcome the appearance of this little book. In the small space of this notice an idea of the book is best given in the author's words, quoted from the preface:

"The descriptive text follows in the main the sequence of topics of Gray's 'Lessons in Botany,' and certain parts in that book have been retained, as occasional paragraphs will show * * * without quotation marks. * * * But the greater part of the descriptive text throughout is new, the chapters on cryptogams and on physiology being entirely so."

"The book offers (1) a series of laboratory exercises in the morphology and physiology of phanerogams; (2) directions for a practicable study of typical cryptogams, representing the chief groups from the lowest to the highest; and (3) a substantial body of information regarding the forms, activities, and relationships of plants and supplementing the laboratory studies."

Laboratory Manual in Elementary Biology—By FREDERICK DEFOREST HEALD, M. S., PH. D., Professor of Biology in Parsons College (Ia.). 14x21½ cm. Willard N. Clute & Co., Binghamton, N. Y.

"The guide is intended for an elementary class of biology, with the work extending throughout the year." That it is specifically for college work is indicated by the further statement of the author: "The directions given in this manual are the result of work that has been done with college students during the past six years."

It aims to be a mean between the extremes of the "question method." The title "biology" seems scarcely to fit a manual that gives only the morphology and anatomy of the types selected, ignoring the physiological side. The types taken up are the thallophyta, bryophyta, pteridophyta, spermatophyta, and then protozoa, coelenterata, vermes, echinodermata, mollusca, arthropoda, vertebrata. L. M.

A University Textbook of Botany. By DOUGLAS HOUGHTON CAMPBELL, PH. D. Pp. xvi—550. Illustrated. New York. The Macmillan Co. $4.00.

This textbook, planned to replace in America that of Strasburger, Noll Schenck and Schimper, is the most extensive in scope of any American textbook in botany which has yet appeared. Its plan briefly stated,

is as follows: After an introductory statement of the elementary problems of the biologic relations of animals and plants, and of the role of matter and energy in the organic body, the plant body and the plant cell receive in turn a considerable treatment. Classification is then taken up at length, the system of Engler and Prantl being chiefly adhered to. The three chapters at the close of the book deal successively with physiology, relation to environment, and geological and geographical distribution.

It is to be regretted that in a work of so much *prima facie* importance the treatment of the different parts should be so unequal. Remembering that quantity and quality are by no means constantly associated, it is at least some indication of the relative value of the treatment of the physiological aspect of botany that only 32 pages out of 550 are devoted to it. The deficiency is in part made good by more or less physiological matter appearing in various places elsewhere, but after perusing the text, we believe that at best, the general criticism remains true, that the work would be much more satisfactory with a more equal treatment.

The same criticism, applied in detail, may also be made of the part on general morphology appearing under the head of the "plant body," an apt enough term for discursive use but lacking the virtue which would warrant its substitution for the still pertinent term "general morphology." For example, the discussion of the thallus is very brief and inadequate, in point of view of the student's needs, and other matters might well have been sacrificed in order to give such topics a fuller discussion. The portion dealing with the plant cell on the other hand is very good indeed.

The bulk of the volume is given, as might well be expected, to special morphology and classification, and of the subkingdoms those of the Bryophyta and Pteridophyta are well done. The result of the author's previous training in these fields has stood him in good stead.

At the opening of the chapter dealing with the Spermatophyta we find a presentation of the subject of embryology, and, though we confidently looked for an account which would give the student a modern view of the subject, we are rather disappointed. We find but a meager reference to the phenomenon of double copulation, so-called; parthenogenesis in the seed plants is not mentioned, though certainly "well authenticated"; but little attention is given to the behavior of the antipodal cells and in this connection it can hardly be said that the "case of *Sparganium* is the most remarkable yet observed" for the condition in the grasses is at least as much so. The concluding chapters on ecology and distribution are brief and summary and are illustrated with several good full-page halftones.

The work is otherwise very fully illustrated, many of the figures being taken from the author's previous publications. Others are from

different sources, some having been redrawn, and some taken from the original plates. There results an exceptionally heterogeneous collection, which is not a necessary objection, perhaps, were it not that many are crude, unjust to the originals, and lacking in significance in such a book. The distribution of the figures is often quite unfortunate, some appearing in text quite foreign to them. This makes appear worse than unnecessary the repetition of some of the illustrations.

To each chapter is appended a bibliography which would be more serviceable if many papers of first importance of American, not to mention foreign, botanists had been cited. It would be no detriment, also, if the citations were correct, which in many cases they are not.

In spite of many criticisms of detail, Professor Campbell's book will be of great value to the college student in botany, although it is far too advanced and detailed for the secondary school. For the high-school teacher, however, it will be a very great help to have a treatise of this kind for reference, and by its means these may familiarize themselves with many groups of plants which are a great deal too little known in secondary work.

FRANCIS E. LLOYD.

Suggestions for Progressive and Correlative Nature Study. By G. W. CARVER, M. AG. Pp. 18; octavo. Tuskegee Institute Print, 1902.—

This little pamphlet is the first number of a series of nature study guides primarily prepared and intended for the students of Tuskegee Normal and Industrial Institute. The author does not offer this work as original, but acknowledges its sources, so far as subject matter is concerned, in the various standard works, to which he has added some features which are the result of his own experience. The purpose of this series is through nature study to bring about the results commonly expected from all our pedagogical labors. The method employed is the laboratory and field method common to the best scientific work in secondary schools. Observation by the pupil, questions by the teacher, collection of the proper material, statement of the necessary fact by the teacher, drawing of the object studied, the drawing of simple but logical conclusion, simple experiments and training in the proper use of language, all have their place in exercises which are grouped so as to lead the pupil from simpler to more complex exercise of his mind. The material chosen for the pupils' work is that to be readily found anywhere about their homes or the school. The experiments are but controlled phenomena commonly occurring all about the pupils in their daily surroundings. The following quotations illustrate the development of the work:

LEAVES.

Exercise No. I.

(a) Are they all alike?
(b) If not, tell me in what way they differ.
(c) Bring a specimen of each one to class tomorrow.

Exercise No. II.

(a) Hold an oak leaf to the light and tell me what you see.
(b) What are the little veins for? (Teacher explain.)
(c) See if the veins in all the leaves are alike.
(d) What plants retain their leaves all winter, and by what general name are all such plants known?
(e) Of what value to the plant are the leaves? (Teacher explain.)

Exercise No. III.

Draw as many different shaped leaves as you can find upon the paper mulberry, and bring to class.

WRITTEN WORK.

Exercise No. XXXI.

(a) Walk briskly for twenty minutes, covering as much territory as possible; tell what you saw.

(Teacher.—Too much stress cannot be placed upon the importance of this request, as the object here is to train the mind to comprehend at a glance what passes before the eye.)

Exercise No. XXXII.

Take a plot of ground, anywhere on the campus, ten feet square, study it for ten minutes, and write the result of your observations.

(Teacher.—Here minute details are desired.)

Several unfortunate little errors of English were overlooked in the preparation of this paper. The text is illustrated by one full-page half-tone from a photograph, and by nine line-cuts by the author.

Teachers interested in this line of work may obtain copies from the author at Tuskegee, Ala.

E. L. M.

Books Received.

Nature Study and Life. By Clifton F. Hodge. Ginn & Co., Boston, 1902. xvi and 514 pages, $1.50.

Animal Forms. By David S. Jordan and Harold Heath. D. Appleton & Co., New York, 1902. vii and 258 pages. $1.10 *net*.

Animal Activities. By Nathaniel S. French. Longmans, Green & Co., London and New York, 1902. xxi and 262 pages. $1.20.

Inorganic Chemistry. By A. F. Holleman; rendered into English by Hermon C. Cooper. John Wiley & Sons, New York, 1902. viii and 458 pages. $2.50.

An Introduction to Physical Geography. By Grove Karl Gilbert and Albert Perry Brigham. D. Appleton & Co., New York, 1902. xv and 380 pages. $1.25 *net*.

Manual of Astronomy. By Charles A. Young. Ginn & Co., Boston, 1902. vii and 611 pages. $2.25.

Elementary Zoölogy. 2nd Edition, Revised. By Vernon L. Kellogg. Henry Holt & Co., New York, 1902. xv and 484 pages. $1.20 *net*.

Life and Health. By Albert F. Blaisdell. Ginn & Co., Boston, 1902. vi and 346 pages. 90 cents.

Reports of Meetings.

STATE SCIENCE TEACHERS' ASSOCIATION OF INDIANA.

The seventh annual session of the association was held in Indianapolis April 25 and 26. The program was of definite value to the teachers of the various sciences.

The special object of each paper was to describe methods used and results obtained by the author in his class work.

The discussion following each paper was animated. Everyone pronounced the meeting a success.

Reported by D. T. Weir.

CENTRAL ASSOCIATION OF PHYSICS TEACHERS.

At a meeting of the physics teachers of about a dozen schools in the spring of 1902, a committee was appointed to ascertain the feasibility of organizing an association among the teachers of physics of the Central States. The responses to nearly five hundred circulars sent out were so heartily in favor of such an association that a meeting was held at Chicago on June 7, 1902, for the purpose of effecting a formal organization. At this meeting, representatives from twenty-five schools being present, a constitution was adopted and the following officers elected:

President, Chas. H. Smith, Hyde Park High School, Chicago.

First Vice-President, Franklin H. Ayres, Central High School, Kansas City, Mo.

Second Vice-President, C. F. Adams, Central High School, Detroit, Mich.

Secretary, C. E. Linebarger, Lake View High School, Chicago.

Treasurer, E. C. Woodruff, Lyons Township High School, La Grange, Ill.

Much enthusiasm was exhibited at the meeting and it was the firm belief of those present that great good would result from such an organization. It was decided to hold a meeting the Friday and Saturday following Thanksgiving and also one during the spring vacation. The features of the meetings are to be (1) an address by an advanced teacher and investigator in the field of physics, (2) short papers and discussions on practical experiences in teaching, (3) visits to laboratories and manufacturing plants, (4) exhibitions of physics apparatus by dealers and manufacturers, (5) informal banquet, Friday evening.

N. E. A. ROUND TABLE CONFERENCE IN PHYSICAL SCIENCE.

MINNEAPOLIS, MINN., JULY 9, 1902.

Mr. W. A. Fiske, Richmond (Ind.) High School, *Leader.*

[The following program had been sent about the first of June to quite a number of different teachers and science men of the country, and it was also distributed among the audience at the Wednesday session of the Department of Science Instruction, which immediately preceded the Conference.]

PHYSICS.

1. Proportional amount of time in a one year's course in Physics, to be given to the following subjects:
   (a) Mechanics, (b) Heat, (c) Sound, (d) Light, (e) Magnetism, (f) Electricity.
2. Relative amount of time given to
   (a) Laboratory Work, (b) Lectures, (c) Recitation, (d) Reviews, (e) Examination.
3. Laboratory Experiments:
   (a) Nature, (b) Selection, (c) Number Required, (d) Educational Value.
4. Qualitative Experiments:
   (a) Place, (b) Purpose, (c) Importance, (d) Number, (e) Value.
5. First Appropriation:
   (a) How Invested? (b) By Whom?

CHEMISTRY.

1. Theoretical Chemistry:
   (a) When Presented, (b) How Much? (c) How Approached, by experiment or dogma? (d) How Utilized? (e) Shall Recent Theories be Taught?
2. Qualitative Analysis in High School course:
   (a) Time Devoted to It; (b) Importance Placed Upon It; (c) Educational Value.
3. Best methods of presenting to beginners the laws of Chemical Combinations and the Atomic Theory.
4. Symbols and Equations:
   (a) Time of Introduction; (b) To What Extent Used? (c) Value Derived by Pupil.
5. Difficulties, how met?
   (a) Inaccuracies, (b) Lack of Chemical Imagination, (c) Drawing Wrong Conclusions, (d) Delaying Records, (e) Borrowing or Cheating.

PHYSICS AND CHEMISTRY.

1. Historical method in Elementary Science:
   (a) What Should be Presented? (b) Where and How Obtained? (c) Amount Presented? (d) Value to Pupil?
2. Supervision of Laboratory Work:
   (a) Relation of Teacher to Pupil During Working Period; (b) Economy of Pupil's Time in Writing Laboratory Notes; (c) How to Obtain a Strict Scientific Interest; (d) Time Given to Note Book Inspection, Quiz and Problem Work.
3. The Laboratory Note Book:
   (a) Attitude of Pupil Toward It; (b) Form of Book to Use; (c) Best Arrangement of Data; (d) Time and Place of Making Record; (e) Educational Value.
4. The Science Library:
   (a) Location? (b) How and When Used? (c) Value to Pupil.

5. Closer Correlation between the Science and English Work:
   (a) Desirability? (b) How Best Obtained?

6. Value of Nature Study in the Grades to High School Science.

MR. FISKE: I see, in looking over the report of last year's conference, that we closed about half past six o'clock. We haven't much time left us, but I hope our interest in the subjects on this program is such that we can at least spend an hour in their discussion. We have given to quite a number the program that has been prepared for this occasion. I have been asked by at least two or three science papers of the United States to furnish a report of this conference, and if any one who takes part in the discussion this evening wishes to have his discussions revised, such may be indicated at the close of the meeting. I have anticipated the shortness of the time and therefore concluded as an introduction to this subject, to take up only a few moments of time and present two or three phases very interesting to me relating to *Physical Science in the High School.*

Physical science as we find it today in secondary schools is the result of a steady evolution. A quarter of a century ago it was taught mostly in a didactic manner, with no thought of a laboratory and with but little experimental work in the lecture room.

The illustrations of the text were examined and carefully discussed, which was, in most cases, about the extent of the apparatus used. Later, when apparatus became cheaper and was more accessible to the average school, experimental work for illustrative purposes was made a part of the daily recitation. Finally, the laboratory was introduced, which added a decided interest to the work and made it much more valuable to the pupil.

All experimental work was at first qualitative in its nature, and inductive methods of presentation were largely employed by those having the work in charge. Recently an inductive text book has been considered out of date, and to maintain its place in the field, of necessity has undergone a careful revision.

Thus we see that the methods of presenting these subjects, and even the tools in many cases, with which the work is done are not fixed, but are subject to wide variations upon the inception of new ideas. That is why we meet here today for the purpose of discussing these subjects in their various phases and obtaining the best each one has to bring.

The relation which the physical sciences bear to certain other subjects of the curriculum is one of extreme interest. As the most important of these, mathematics, English and drawing may be named.

There was a time when physics and chemistry, instead of being mathematical, as at present, were more philosophical. The problem was but little known while much time was spent in reasoning upon obvious natural

phenomena. It is not so now. The text book on these subjects, especially physics, that is not rigidly mathematical is looked upon with some doubt as being the proper one to use in the upper classes of our secondary schools.

In view of this condition of things, it is of advantage that the department of mathematics recognize the needs of pupils beginning the subject of physics. The hare-and-hound style of problems in algebra is in a measure being displaced by those of a more practical value—by instruction and drill upon principles that will be of far more advantage further on in the course.

It frequently happens that a pupil having three terms of algebra and one or more of geometry is tripped up on the solution of a simple equation in the subject of physics. This, however, is not a fault of the mathematics teacher any more than of the teacher of physics. The fault, we believe, lies in the fact that the pupil is permitted to regard the subjects of mathematics and physics as two separate and distinct things with no relation whatever existing between them.

The pupil has finished his mathematics, as he thinks, and begins the subject of physics, to him a new field, little thinking he can use the old tools to continue his work.

The same close relation should exist between the departments of English and drawing, because of the great value of each to the work in physics, while the latter may be made most helpful to the work of these two departments.

There seems to be a growing tendency in some schools to make the work easy, as it is called. A teacher the other day said: "I have one child and if she passes in her work and has a good time while doing it I shall be satisfied." If "a good time" means a thorough entering into the spirit of the work, a high appreciation of all the school is able to give and a proper bearing under its rules and regulations, the statement may be an appropriate one; but if the ordinary meaning of "a good time" is understood, this, then, is certainly not the proper attitude to take. It vitiates the school and inculcates in the mind of the child improper notions of life. The school is not the place to have a good time, but a place where one may come up against difficult things. The work should have enough of severity about it to command the highest respect of the pupil and at the same time should be made so interesting and attractive by the teacher that it will be a pleasant rather than an irksome task.

A few, it is true, do fall by the wayside, but such results, upon investigation, are nearly always found to be due to outside disturbances rather than to good, wholesome and well regulated study.

The work of physics and chemistry then should be made difficult. It should mean something. The laboratory should be made a place of good

substantial results, and not a place of amusement. To this end the work, especially in physics, should be purely quantitative in its nature, in which case the pupil will have greater respect for what he is doing, and will find greater pleasure in it because of the definite result he is able to obtain.

The voluminous condition of the majority of text books is a problem with which the teacher has to deal, and unless a judicious pruning is resorted to, the work cannot be efficiently done. This is especially true where one-third to one-half of the time is devoted to laboratory work. An attempt to cover too much ground in one year, either in the laboratory or class room, is, we believe, a serious fault and one which results in many bad habits on the part of the pupil. The work is poorly done; much of it is unfinished and unmastered; the pupil fails to appreciate the importance of the subject and falls far short of one of its prime purposes—the development of a scientific attitude of mind. The aim, we believe, should be to spend the time allotted to a given subject upon the most important parts of the text and then use all possible means to have the pupil appreciate and master the work assigned him. What these most important parts are, is involved in the first question for discussion this afternoon—the proportional amount of time in a one year's course in physics, to be given to the following subjects: Mechanics, Heat, Sound, Light, Magnetism and Electricity.

There was a time when I felt that the greater portion of the school year should be spent upon Electricity, but I do not think that way now. I do not know what others think, but it seems to me that the best results, from my own observation, are obtained from a careful study of Mechanics and Heat; therefore, it might be well to spend at least half of the time upon these two subjects, a fourth of the time given to a thorough consideration of the general principles of Sound and Light, and perhaps about as much time on Electricity as upon those two.

We will now leave the first subject open for discussion, and during the discussion if it is the desire of anyone to take up some other topic, that may be done.

Mr. Willis E. Tower, Englewood High School, Chicago: I am very sorry our time is short, but I agree with our chairman that Mechanics and Heat should occupy half the time, but I am not quite ready, however, to give Electricity any less time than is given to Sound and Light. I cannot discuss this outline as I would like to, as I am sure it would interfere with what others would have to say. I would like, therefore, instead of discussing it to make an announcement which will doubtless not be news to a good many who are present, and that is that there was formed last month a Central Association of Physics Teachers, along the line of the Eastern Association of Physics Teachers. Many of you doubtless know of this and perhaps some of you were present at its formation. And some of you are familiar with the magazine, School Science. The

editor of SCHOOL SCIENCE is the secretary of the association, and its president is Chas. H. Smith of Hyde Park High School, Chicago. Its first regular meeting is to be held next Thanksgiving vacation at the Lewis Institute, Chicago, and among the speakers will be Prof. Carhart of the University of Michigan. I believe this Central Association of Physics Teachers will be of great assistance to physics teachers in secondary schools and colleges in getting together along the right lines of physics teaching.

MR. F. L. BARKER, Chemistry, Duluth: There is one thing here in chemistry I would like to speak of and that is Qualitative Anaylsis in the High School Course; and I would like to raise a protest against teaching qualitative analysis in the high school. It seems to me it is entirely out of place. In the first place, we can't teach very much of it; and in the second place, to those who are going to college it will do no good, for they will immediately have to take the work all over that we have given them and those who are not going to college cannot get enough to amount to anything. In many of our states we have large mining interests. The development of these and the chemical problems that confront the mining engineer or the pupil who has any interest whatever in mining work are of prime importance to that pupil; and that teacher who is so situated that he can teach to pupils in a mining country has an opportunity not to be neglected for practical work along the lines that are of great importance to that pupil. On the other hand, if one is teaching in a manufacturing country, there is a great field open for manufacturing chemistry and the practical application of chemicals to everyday life. Enough work can be given to cover two or three years of general chemistry, with all of the practical applications you might make. We hear a great deal of industrial education, but it seems to me that the man who is teaching chemistry has the best chance in the world to give industrial application.

I just want to raise this protest against qualitative analysis in the high-school course.

MISS JESSIE F. CAPLIN, Chemistry, Minneapolis, Minn.: There is one statement about qualitative analysis that I would like to speak of. You say the pupils must take the work over if they go to college. If we give them a proportion of the whole year in chemistry they must take the whole year over again in the academic course. My experience has been (and I send perhaps 90 and perhaps 150 of my pupils over to the university) with the qualitative analysis first that the general chemistry is a great deal stronger because they have had chemistry before. Of course we can't cover it. Of course we can't take anything but the simplest reactions; but that makes the work that much easier—that much less that they have to do when they get to the university; and therefore, they can expend that much more strength on the harder reactions, it seems to me.

Miss Clara Struble, Physics, Bismarck, N. D.: I would like to have someone answer the questions involved in 2, 3 and 4.

Mr. Fiske: The nature of laboratory experiments, I am convinced from experience, should be quantitative. There may be a few qualitative experiments introduced, but there is not that opportunity for thought on the part of the pupil obtained from qualitative experiments in the laboratory. The time in the class room, according to my notion of the matter, should be partly taken up with qualitative experiments to illustrate the work. The number of laboratory experiments required should perhaps be as many as 35 or 40 during the year. If this number of good quantitative experiments in the laboratory is worked by the pupil during the year, pretty fair work in that subject is being done.

Some people do not believe very much in reviews. That may be true with older pupils, but with younger pupils it is well to review some. As far as examinations are concerned, I hardly ever give any. I take, in a measure, my knowledge of the ability of the pupil. I try to impress upon the pupil's mind that his interest and enthusiasm in the work are the main factors upon which I depend, occasionally giving a test on some particular phase of the subject. But what we call real, old-fashioned examinations, I haven't much sympathy with.

Q. You say you give no tests or examinations. Do you attach any importance whatever to the mathematical problems in connection with these different subjects?

Mr. Fiske: Yes, very much. The subject is very nearly all mathematical. As I stated before, modern text books, or at least the best ones (I think I am not wrong on this) are very mathematical, and that is the kind of text book I believe in. But to set aside a certain time at the end of the month or at the end of six months or at the end of the year for a good long, stiff examination to cover the whole subject, I do not think, the better plan.

Mr. H. A. Bbitzius, Physics, C. H. S., Minneapolis, Minn.: I would like to have a little bit more information in reference to the time to be given to laboratory and recitation work; and to bring up the subject, I am willing to state about the time given in Minneapolis. As far as laboratory work and the recitation work are concerned, we try to divide the work equally. Now, then, as to lectures. It has been my aim to have the pupils feel that after they have completed a recitation they should be frank enough to admit that they did not understand the subject; and right in that connection is where I aim to get in my lecture work.

Then as to reviews. While I believe in reviews, I find that my time is so limited that I cannot give much of it to reviews, but then I believe in taking tests and then the student is obliged to cover a specific part of the work we have gone over and be prepared on anything that may come up under that part of the subject; and my aim generally is to divide tests

up very much as they have been given here. And whenever they have completed that part of the subject I have them review the whole and come to me if they have any difficulty, but when the test is given, then they must be sure they understand the whole subject. Now I wish to say in connection with this that I do not believe in giving them credit on tests alone. I generally aim to have the recitation count for about half and the test for half—try to average them up—as my experience is that while some students seem to be bright in daily recitation, their memory is shorter than others and so when the test comes, unless they have very thoroughly prepared, I find they have forgotten some things. Some are good talkers to recite and others are good writers, and *vice versa*. So that is the plan we pursue very largely. Now then, I have stated this to get opinions from someone else.

MR. F. E. GOODELL (N. D. M. High), Des Moines, Iowa: There is one topic which has close connection with the one which we outline here. The examination has been spoken of. In this connection I would like to ask just what it should be, whether in the nature of questions or problems? My own practice is to include a large number of problems in these tests which I give. I believe in these things. I believe problems bring out principles and prevent that memory work which is the same in all science work. If the pupil can get the problem, he is almost sure to have the principle involved in that problem; he can't work it unless he has. So that in testing pupils' ability—the way in which they grasp the subject—I emphasize the problem and seek, as far as I can, to select such problems as will cover the subject most thoroughly and will bring out their grasp of the principles which it involves.

Q. Where should the qualitative work of physics come in?

MR. FISKE: The place for qualitative experiments is certainly in the class room. Occasionally it is advisable, it seems to me, to work a quantitative experiment in the class room, but that can't be done very extensively because of the lack of time, but to illustrate the subject matter of the text, it is essential that this be the place for these experiments. It is true that the number of qualitative experiments cannot be very great because of the lack of time. It takes a long time in the class room to work very many experiments, and the average text book is so full of them that it is almost impossible to work all that are given, but the chief experiments in the text book and many that are not can be introduced to illustrate the subject under discussion.

Q. Did I understand you to say that the qualitative experiments should be worked chiefly in the class room and the laboratory experiments should be quantitative?

MR. FISKE: That, I think, is the proper way.

(To be concluded in November.)

Correspondence.

EDITOR SCHOOL SCIENCE:

I have been interested in reading a recent article on "Magnetic Phantoms" in your paper. I have used a simple method, which I find very convenient and satisfactory. A piece of blue print paper is spread out over the magnet, and sprinkled with iron filings by means of a muslin bag. The entire apparatus is then placed in the sunshine for a few minutes, then the blue print washed in the usual manner. The method does not require a dark room, is fairly rapid, and well adapted to individual laboratory work.

B. G. SMITH.

Science Teacher, Corry (Pa.) High School.

EDITOR SCHOOL SCIENCE:

In a letter on the food value of alcohol, in the April number of SCHOOL SCIENCE, the writer seems to assume that we are obliged to admit the correctness of Professor Atwater's claim, that alcohol is a food. Is this true? Professor Atwater asserts that his experiments show that a certain amount of alcohol can be assimilated in the human body, and threfore concludes that it is a food. But Professor Atwater could not show that *all* of even a small amount of alcohol taken into the system could be assimilated. In fact, we are obliged to admit, not as the result of a few experiments, but as particularly proved by the experience of hundreds of thousands, that the larger part of the alcohol taken into the stomach, even in small amounts, acts as an irritant and a disturber of the normal functions. J. W. Long, M. D., in the Carolina Medical Journal, says: "Food warms the body; alcohol radiates more heat than it generates; alcohol increases nitrogenous metabolism, while food conserves the proteids. Food replaces tissue waste and adds to tissue growth; alcohol does neither. Food builds up, alcohol tears down. Food is nature's means to sustain life, alcohol is a protoplasm poison and destroys life. Food makes a normal man; alcohol makes him abnormal. Food does not produce degenerative changes, disease and death; alcohol does all, and more."

Let us remember, also, that Professor Atwater's conclusions have not been accepted by other great students of the question, but have rather been condemned by them .

HARRY CLIFFORD DOANE.

Grand Rapids, Mich.

School Science

VOL. II] NOVEMBER, 1902. [No. 5

SCIENCE TEACHING PREPARATORY FOR THE HIGH SCHOOL.

BY HERBERT BROWNELL,

Department of Physical Science, Nebraska State Normal School.

With demands for college entrance becoming more and more exacting in the sciences, with a better appreciation of the value of laboratory science for students who cannot hope to go beyond the high school, and with little opportunity for increase in time allotted the sciences in the high-school courses, teachers of high-school science have seemingly been slow to demand of the grades below the preparatory elementary science teaching needed not only by the children who in so great numbers fail to go on into the high school, but as well to make possible in the high school that quantity and that character of science teaching now demanded there. Teachers of science very generally are agreed in claiming for the sciences a training value, both in the observation work under direction and in the processes of comparison and reasoning based thereupon, not possible in other branches of study; an independence in thinking to conclusions and an exercise of that self-initiative in thought and action demanded of men and women outside the school room and gained in no other school work so well.

There is very general agreement, too, that the "scientific attitude" of mind in the boys and girls entering the high school is too often wanting, that readiness to discern the facts that are presented; that ability to trace the relation of cause and effect and to discriminate between the important and unimportant; that power to state just what is observed rather than preconceived notions of what ought to have been seen. There is wanting an independence in thinking out for one's self from facts in hand the relations of

these facts and their significance; instead, there is too commonly a blind acceptance of the statements of another of what the facts are and what their teaching is. It is not infrequently the case that students come into our classes who for a whole term, perhaps, are almost helpless without a text from which to quote, and who awaken so slowly to a realization that they are capable of seeing each for himself, of thinking each for himself to definite conclusions, of giving expression to thought in form largely or wholly original; they find it so difficult to understand that the text is to supplement and not supplant their efforts both perceptive and apperceptive.

The study of the natural sciences demands in full all the maturity of the average high-school student. To make possible the most and the best science work in the high school demands likewise that in the grades below, from the kindergarten up, there shall have been that continuous course in which are taught those forms and phenomena of nature that are of the everyday experiences of all. From such general science lessons, slowly, perhaps, but surely, should come literally a *leading forth* of the powers of the senses and of the mind—a keenness in observation, an alertness of mind, readiness and independence in thinking, and, withal, that right "attitude" so prized by the science teacher.

It seems strange that science teachers have not long since demanded that before entrance upon high-school work there shall have been through the grades a line of continuous science teaching based upon and an outgrowth of the experiences and experiments of the children and of widely varied character. The choice of topics for such a course is not a question of what particular science shall be taught to the exclusion of any other; it is not that the particular facts taught shall be labeled physics or botany, but that they be of the surroundings of the children and likely to promote an abiding, life-long interest in these surroundings, an interest ever stimulated by the satisfaction coming of fuller comprehension.

There has been a great deal of discussion of how much of this or that science shall be taught in an elementary way, with a very general failure to agree upon anything definite to be required in the grades as science teaching. The fact is too often lost sight of

that the work in the grades is to be nature lessons, and not any particular science or sciences, however elementary; that whatever nature forms or natural phenomena, suited to the children to be taught and directly related to them through daily experiences, are chosen as topics, it is to be a choice regardless of what particular branch of science may be therein represented; the amount and character of the inductive reasoning involved therein, however, count for much.

It is greatly to be regretted that nature study, so-called, should have fallen into such disrepute among science teachers, and more's the pity, with so much reason therefor. It is too commonly the case that all distinction between a study of nature and a study about nature is lost; books telling what someone else has seen and what someone else has thought of the same may be both interesting and instructive, and have a proper place and use, but this is not nature study. To be master of one's surroundings in life, able to use them aright and to one's own best good and general success, requires some measure of ability to note conditions, to see relations, to reach definite conclusions quickly, independently and with few errors of judgment. All this requires of an individual not only some measure of natural aptitude, but, as well, that training which the school may give and give best in the study of nature first hand, day by day, through all the grades to the high school. It is this training and fitness that science teachers in the high schools need in their pupils and must demand if they in turn would meet the demands made upon them.

High-school teachers of science must protest against a mass of so-called nature study, more or less sentimental and worthless, for the sake of their own class and laboratory work, as well as in behalf of long-suffering pupils, and must not be content simply with treating lightly this farcical science teaching, or passing it by with silent contempt. Nature-study readers, the study of poems about nature, stories of animals or of industries, the fairy tales of social converse among birds, beasts, flowers, above all the abominable nature-study "lessons" and "plans" to be found too frequently in the school journals, are one and all to be subjected to the same rigid tests of whether they require of the pupil and secure to him the benefits of a training under direction in the use of the powers

of sense, of mind, of expression. Lessons having as their purpose the cultivation of the æsthetic, of love for animals and plants, an interpretation and appreciation of literary gems or pictures about objects of nature, all are incidental, and whatever their respective merits and whatever their relations to science work in the grades, they are not to be substituted for it any more than for arithmetic. Lessons upon our bodies, their parts, with uses; the preservation of health, with its topics of ventilation, sanitation, choice and preparation of foods, exercise, right habits of life, etc., are to be given, but with little of the anatomy and biology often found in school physiologies. Physiology as a science, if so taught, belongs higher up. So too geography, that many-sided subject, will serve well as a center about which to group and to which to correlate the science lessons. It may well provide the text work to accompany and to be included in the course of science lessons which otherwise are largely oral, partaking in nature of laboratory exercises and prepared both in and out of school.

Two difficulties stand in the way of the realization of such demands by high-school science teachers. One of these is lack in the grades of teachers who themselves have had even the common high-school branches of science properly taught. How absurd the attempt to teach nature study by one who herself neither knows what is to be seen by the children, or its significance if seen! Unable to choose wisely subject matter or to guide aright the children, the only recourse is to feed them instead the husks of dry fact taken from some book, or to employ the time in "talks" with the children whose value as a means toward the development of an intelligent observation of nature and a training for high-school science work is of doubtful value, to say the least. The high schools must give to their graduates, certainly those who are to teach, that knowledge of the sciences rightly acquired, which shall in turn make possible the kind of science teaching desired in the grades. Normal schools can never, because of their short courses, make good any such lack.

Another stumbling block, but fortunately one that high-school teachers can themselves remove, is the need in the grade teaching of such lesson plans, lesson outlines, such selection and arrangement of subject-matter as shall enable the busy teacher, very

largely lacking in facilities for science teaching, to have always in hand the material for the series of science lessons required in her particular grade by the course of study. Simple experiments must be given in detail, together with the successive steps of development of topics, and those directions and suggestions whereby the grade teacher of ordinary ability and limited knowledge of the sciences, working under the usual conditions of the grade schools, may not feel herself compelled by circumstances *to tell the facts* to the children, and drill upon these till the words are memorized, or to make use of a text to the same end. Such teaching has little or none of that training value and development upon which science teachers lay so much stress; the robbery of the children in opportunity and in result is analogous to their loss physical were teachers and textbook writers to kindly relieve them of the task of eating and exercising.

Many a teacher with usable "aids" whereby to get and to keep clearly in mind the spirit and purpose of these nature lessons, so very unlike the usual recitation and class drills, getting once started aright would make the science work in the grades a success even with little knowledge or training herself in the sciences. The book or books to meet this need must yet be written, and high-school science teachers should not be slow in agreeing among themselves upon both the ends to be attained and the means employed in science teaching in the grades.

THE HISTORY OF ZOÖLOGY TEACHING IN THE SECONDARY SCHOOLS OF THE UNITED STATES.*

BY MARION R. BROWN,

The Erasmus Hall High School, Brooklyn, N. Y.

[A Contribution from the Department of Biology, Teachers' College, Columbia University.]

(*Concluded from page 209.*)

The division between the second and third periods was marked by the publication of a small book entitled "Practical Zoölogy," by Buel P. Colton, of the Ottawa High School, Illinois. This book was the culmination of those tendencies toward laboratory work which have been noted in the years just preceding. This book is noteworthy in the history of zoölogy not only because it is the culmination of tendencies which have been active through previous history, but because it stands for a method which with modifications is the strongest characteristic of twentieth century teaching and bids fair to continue indefinitely into the future. This book was the first of many laboratory manuals which have since been placed upon the market. The aim, as stated by the author in the preface, was "to aid students in getting a clear idea of the animal kingdom as a whole by the careful study of a few typical animals." Here are found two tendencies which may be traced through Morse and Packard: (1) the study of a few selected animals rather than a heterogeneous perusal of the whole animal kingdom; (2) the slight importance of the starting point in accomplishing the final result. These theories are exemplified in practice by Morse and in theory by Packard. In Colton's book the first definite and successful attempt was made to conduct a systematic study of the whole animal kingdom by means of types. Each animal selected as a representative of a group is fully treated both as to morphology and anatomy. The grasshopper is the first specimen studied and establishes a basis for [illegible] work. The order is from the grasshopper, through the [illegible] worm and mollusks to the crayfish. The vertebrates are treated in ascending order, and last some space is given to [illegible] reptiles, birds, mammals and amphibians. The book

* Thesis presented for the degree of Master of Arts, Columbia University, 1910.

consists principally of directions for the study of external anatomy and dissections. It calls for better equipment than had heretofore been required in the pursuit of zoölogy. In addition there are brief accounts of the natural history and development, although these are of very minor importance as compared with structure. Classification is treated in the light of Morse's remark previously quoted, that "there is no use in studying classification until the pupils know something to classify." One point is to be noted in this book which sharply differentiates it from previous works. Almost the first thing observed is the total absence of illustrations. There has been a development in illustrations to correspond with the development of subject matter, and upon the appearance of laboratory manuals they disappear entirely. This is to be accredited to the growing idea that the child is to see for himself, make his own drawings accordingly and form his own conclusions from what he sees. Observation and investigation are now the prevailing principles of work, and consequently all which interferes with their advancement is eliminated. This book, which so completely revolutionized the teaching of zoölogy, held the foremost place among zoölogical text books until the appearance of Boyer's "Elementary Biology" in 1894, when it was partially supplanted, but even today holds a place of some importance.

The old text-book method, however, was not to be done away with suddenly, and in the same year with Colton's book appeared another text book constructed on the plan of many predecessors but with a few improvements. The pupil is to study the text and verify its statements by means of "living animals in menageries and other convenient places." Like all of Steele's books in science this one attained considerable popularity and was widely used for a number of years, but exerted no permanent influence on method in biological teaching. A stronger sentiment was growing that zoölogy was a valuable subject for mind training and general culture and also that the text-book method was inadequate to bring out its full value. In the Report of the Commissioner of Education for 1888-89 is incorporated a portion of an article by David Starr Jordan, then president of Indiana University, taken from the *Popular Science Monthly*. In this

quotation Pres. Jordan says that "the essential of method is to allow nothing to come between the student and the object which he studies." He also clearly states that "the text-book method is of no value."

The Committee of Ten in 1892 reported to the National Educational Association that the minimum of natural history, meaning biology, for high schools should be one year of daily recitation and laboratory work and that it would be better to concentrate the attention throughout the year on either botany or zoölogy rather than to give a half year to each. If zoölogy were chosen the proportion of recitation to laboratory work should be in the ratio of one to three. Packard's suggestion of studying the fish first and making it the basis for comparison in future study was adopted, but after the study of the fish was completed the animal kingdom should be treated in ascending series.

Mr. Boyer in his "Laboratory Manual in Elementary Biology" expanded Mr. Colton's idea and endeavored to meet the demand of those secondary schools which desired to combine the subjects of zoölogy and botany into a continuous one year course, making laboratory work the basis. The book deals with animal and plant morphology and requires of the pupil but little dissection. It is somewhat more extensive than Colton in that it gives in addition to directions for work topics for further study of each type selected and a complete bibliography for study at the end of the book. The arrangement is strictly systematic. The first lesson is on the construction and management of the compound microscope. It is followed by the study of the lowest forms of life, demanding too acute observation for those unskilled in the use of the microscope. Both Colton and Boyer were valuable guides to teachers whose knowledge and experience in biology were limited, because they indicated material and places and times for obtaining it and reference books for the use of both teachers and pupils.

The last five years of this third period of secondary zoölogy teaching were years of great activity and resulting great progress. By 1895 zoölogy had been recognized, at least among schoolmen, as a subject of value and importance in the curriculum. There was tacit agreement that science was one of the three important

lines of work in secondary schools and zoölogy with a history of seventy years was taking its place among other sciences, though the least favored of them all. The question had ceased to be "Shall we teach zoölogy?" or "Why should we teach zoölogy?" but "What method shall be used?" and "At what time in the school course can it be studied most advantageously?" The National Education Association as well as other educational bodies of less influence, was busied with these problems and has continued so to the present day. Three conditions have given botany the preference over zoölogy: (1) the claims of botany to accord with the child's tastes and to adapt itself to the uses of high-school pupils; (2) botany is better suited to general school equipment and preparation of the teacher; (3) college entrance requirements usually include botany rather than zoölogy. When zoölogy is required at all it is usually evident that it is mere book work. This naturally did not improve the character of zoölogy teaching.

In 1895 two new text books appeared and various aspects of the subject were discussed in educational meetings and magazine articles. The conception of biology had broadened so that it was now regarded as a source of education rather than the mere knowledge of plants and animals. The following are the results enumerated by Mr. Alfred J. McClatchie in an article in the March number of the *Popular Science Monthly* for 1895: (1) correct observation; (2) correct expression through (a) drawing, (b) notes, (c) oral discussions; (3) moral development (intellectual honesty); (4) power to generalize; (5) power to reason; (6) scientific imagination; (7) power to discover truth and acquire knowledge; (8) appreciation of the beauties and harmonies of nature; (9) information concerning life and its problems which will be useful in any occupation afterward chosen. Compare for a moment this conception of the possibilities of zoölogy with those held earlier. All previously set forth during seventy years are included in results 1, 2, 4, 5 and 8, and all of these are not enunciated at any one time. In early years 8 was the only one of importance. Gradually 1, 2, 4, and 5 were advanced, and after a time the religious meaning of 8 sank into abeyance. Not until 1895 are all united as integral parts of the real purpose of biology study.

The laboratory method had quite superseded any other method, if not in actual practice, at least in recognition of its superiority as a means of instruction, and attempts were made to approximate its fulfilment when facilities were not offered for its complete development. The text books of the year were Burnet's "School Zoölogy," and Needham's "Elementary Lessons in Zoölogy." The former is a book intended to be used as a basis and guide for class work but by no means to the exclusion of other work. The author urges as necessary to successful results field excursions, collecting, dissection by the class and free use of reference books, of which a list is given at the end of each chapter. The latter is practically a laboratory manual but differs from both Boyer and Colton in that it combines general laboratory directions with descriptions of the habits and development of animals. Both books are illustrated, Burnet's more copiously than Needham's. The latter contains "only such as the pupil cannot make for himself." The illustrations are of various kinds, showing natural history, morphology and anatomical structure in accord with the nature of the text. Both books show a slight reaction against the stern comparative anatomy of the past decade and include a more general study of animals, including physiology, classification and natural history, although this last is but slightly treated.

The study of the psychology of adolescence influenced very considerably the understanding of method in zoölogy as well as giving an impetus to it as a subject supplying the necessary means for developing certain powers.

Among the psychological principles most effective in shaping zoölogical aims was that of habit. Certain habits, mental, moral and physical, which should be of the greatest usefulness could be formed by the study of zoölogy. The means for the cultivation of these habits were found to lie in a combination of laboratory with field and text-book work. The mental habits which can be formed by the study of zoölogy are accurate observation through all the senses, power to distinguish essential from non-essential, careful study of a question before drawing conclusions, reason and judgment. Moral habits may be summed up in the following order: unwillingness to judge without sufficient data, desire

for truth. Physically, laboratory work in biology, as in other sciences, cultivates skill in manipulation. Such a conception made these five years of which we are speaking a time for deep and serious consideration of the best methods of procedure, and keen thought and discussion have brought about various changes, as well as aided in popularizing the subject.

It was becoming more clear to all thinkers on the subject that no one part alone could give a complete idea of the whole, but that anatomy classification, embryology and natural history must all play their part in order that a correct idea might be formed of any one of them. Amongst these broad and liberal views there was a tendency toward the revival of natural history, for so many years superseded by comparative anatomy. Its growth was paralleled by that of other topics but it was destined in a few years to stride ahead of them and again form the basal structure for the study of other aspects. In conjunction with the advance of natural history there grew up also a tendency to confine anatomical study to external features. There were so many other things of importance that time was insufficient to go into detailed study of internal parts and so it was largely omitted. An animal was regarded as an active organism and the first things to be found out about it were the answers to the child's earliest questions, "What is it? and what does it do?"

In the midst of this period of progress, in the year 1897, Kingsley's "Elements of Comparative Zoölogy" was published. This was the extreme of the movement in comparative anatomy which had been in progress for more than thirty years. The movement toward other methods had proceeded too far, however, for the book to meet with great success and it was shortly followed by a book which represented more nearly the spirit of the times. Kingsley's book gives a systematic treatment of the whole animal kingdom, making the fish the basis for comparative work. Vertebrates are first taught in ascending series and then the invertebrate from the complex to the simplest. The book contains laboratory directions for the study of a series of types easily obtainable and gives descriptive accounts of related forms. By combining laboratory guide with a general outline of zoölogy it emphasizes the comparative side. The method of study is in-

ductive. In selecting types the author has considered four things: (1) locality and availability of animals; (2) average ability of students; (3) macroscopic character of the work; (4) consideration of most important facts. The book had an extensive sale for a short time because up to the year 1899 morphology was still the principle subject taught under the title zoölogy. In the January number of *Science* for that year Prof. Conklin wrote "Time was when zoölogy meant merely classification; at present it means little more than morphology." In this same article, however, he notes that the tide is turning more and more to living things.

In the year 1900 there appeared from the press of the Macmillan Company an "Introduction to Zoölogy" by Prof. Davenport, of the University of Chicago, which, we may prophesy, marks the beginning of a fourth period in zoölogy teaching. The book is so complete a departure from anything of recent date that its advent was marked, and it is already running through its fourth edition. This is a bold attempt to restore old-time natural history in a new light, and the twentieth century has yet to prove the success and duration of the movement. Prof. Davenport treats the subject systematically from the natural history side, treating very briefly development, and still more briefly morphology.

During the past year another book has been published which is more representative of the present period than Prof. Davenport's. Kellogg's "Elementary Zoölogy" includes all the various phases of zoölogy, so that the student is enabled to get a broad and comprehensive view of the animal kingdom, learning "something of the functions of animals and something of their life history and habits," and getting "a glimpse of the significance of his particular observations and of their general relation to the animal kingdom as a whole." The author acknowledges in the introduction the value of field, laboratory and recitation work in a course in elementary zoölogy, and urges that each has its place in the course, but says that it is impossible to include directions for all in a text book. The text deals with anatomy, classification, embryology and natural history with laboratory directions for dissection.

A text book in these days, however, does not mean the same thing that it did fifty, twenty-five, or even ten years ago. Instead of being the main dependence as a source of knowledge, it is but one of a number of sources, and not at all the most important one. It is rather for supplementary reading after the subject has been studied as fully as possible from the real object in the laboratory and in the field. There is a continued spread of laboratory and decline of rote instruction, and in this connection a text book is useful only as a reference book unless it be as a laboratory manual. Teachers, as they become better acquainted with their subject, find that a laboratory manual is limited in its adaptations to the conditions under which they are working, and so they are undertaking to make out their own laboratory directions. "The wider use of the inductive investigating spirit is shown in the growing custom of placing new matter before the student in the form of problems so arranged that solution is just within the scope of his own powers." These are the words of Prof. Ganong in the number of *Science* for January 20th, 1899, in relation to botany teaching, and the same is as true of zoölogy as of botany. The number of good reference books in all departments of zoölogy is now so large that better knowledge can be culled from them under wise guidance than one small text book can afford.

The laboratory method itself, which has lived now through upwards of fifteen years, has not come through unchanged. From verification it has passed to investigation. It has become more flexible and more readily adapts itself to varying conditions. The day of laboratory guides is passing, but in its place is coming dynamic work, entailing greater attention to physiology and function.

The last seventy-five years have seen great advance in the teaching of zoölogy. Three lines of improvement have been noted: (1) In aim it has progressed from the narrow ideal of religious and memory training to the broader conception of mental, moral and physical development according to the most recent physiological and psychological researches. (2) Subject-matter has broadened through the discoveries of eminent naturalists, as, for example, Darwin, Huxley and many others of less prominence.

Better knowledge has enabled educators to take a more comprehensive survey of the subject and select from the whole the most important parts and arrange them in their proper relations. (3) The method of presentation has passed through three stages, (a) narrative, (b) classification, (c) morphology, and is just now entering upon a new phase which may be called investigation. Although zoölogy dates back to the time of Aristotle, the study of it was entirely neglected during many succeeding centuries, and not until the time of Pestalozzi was it made a part of the school curriculum. Its greatest progress has been during the past twenty-five years, when it has shared with other subjects in the general advance in education. It is at present more active than at any time in its history, and the future gives promise of greater things than the past has seen.

THE PRELIMINARY EDUCATION OF THE ENGINEER.*

BY JOHN PERRY.

When a man has become a great engineer, and he is asked how it happened, what his education has been, how young engineers ought to be trained, as a rule it is a question that he is least able to answer, and yet it is a question that he is most ready to answer. He sees that he benefited greatly by overcoming certain difficulties in his life; and forgetting that every boy will have difficulties enough of his own, forgetting that although a few difficulties may be good for discipline many difficulties may be overwhelming, forgetting also that he himself is a very exceptional man, he insists upon it that those difficulties which were personal to himself ought to be thrown in the path of every boy. It often happens that he is a man who is accustomed to think that early education can only be given through ancient classics. He forgets the dullness, the weariness of his schooldays. Whatever pleasure he had in youth—pleasure mainly due to the fact that the average Anglo-Saxon boy invents infinite ways of escaping school drudgery—he somehow connects with the fact that he had to learn classics.

*From an Address to the Engineering Section of the British Association for the Advancement of Science, delivered by Prof. John Perry, M. E., D.Sc., LL.D., F. R. S., President of the Section, at Belfast, September 11th, 1902.

Being an exceptional boy, he was not altogether stupefied, and did not altogether lose his natural inclination to know something of his own language; and he is in the habit of thinking that he learned English through Latin, and that ancient classics are the best mediums through which an English boy can study anything.† The cleverest men of our time have been brought up on the classics, and so the engineer who cannot even quote correctly a tag from the Latin grammar, who never knew anything of classical literature, insists upon it that a classical education is essential for all men. He forgets the weary hours he spent getting off Euclid, and the relief it was to escape from the class-room not quite stupefied, and he advocates the study of pure mathematics and abstract dynamics as absolutely necessary for the training of the mind of every young engineer. I have known the ordinary abominable system of mathematical study to be advocated by engineers who, because they had passed through it themselves, had really got to loathe all kinds of mathematics higher than that of the grocer or housekeeper. They said that mathematics had trained their minds, but they did not need it in their profession. There is no profession which so much requires a man to have the mathematical tool always ready for use on all sorts of problems, the mathematical habit of thought the one most exercised by him; and yet these men insist upon it that they can get all their calculations done for them by mathematicians paid so much a week. If they really thought about what they were saying, it would be an expression of the greatest contempt for all engineering computation and knowledge. He was pitchforked into works with no knowledge of mathematics, or dynamics, or physics, or chemistry, and, worse still, ignorant of the methods of study which a study of these things would have produced; into works where there was no man whose duty it was to teach an apprentice; and because he, one in a thousand, has been successful, he assures us that this pitchforking process is absolutely necessary for every young engineer. He forgets that the average boy leaves an English school with no power to think

†The very people who talk so much of learning English through Latin neglect in the most curious ways those Platt-Deutsch languages, Dutch and Scandinavian, a knowledge of which is ten times more valuable in the study of what is becoming the speech of the world. And how they do scorn Lowland Scotch!

for himself, with a hatred of books, with less than none of the knowledge which might help him to understand what he sees, and he has learned what is called mathematics in such a fashion that he hates the sight of an algebraic expression all his life after.

I do not want to speak of boys in general. I want only to speak of the boy who may become an engineer, and before speaking of his training I want to mention his essential natural qualification—that he really wishes to become an engineer. I take it to be a rule to which there are no exceptions that no boy ought to enter a profession—or rather, to continue in a profession—if he does not love it. We all know the young man who thinks of engineering things during office hours and never thinks of them outside office hours. We know how his fond mother talks of her son as an engineer who, with a little more family influence and personal favor, and if there was not so much competition in the profession, would do so well. It is true, family influence may perhaps get such a man a better position, but he will never be an engineer. He is not even fit to be a hewer of wood and drawer of water to engineers. Love for his profession keeps a man alive to its interests all his time, although, of course, it does not prevent his taking an interest in all sorts of other things as well; but it is only a professional problem that warms him through with enthusiasm. I think we may assume that there never yet was an engineer worth his salt who was not fond of engineering, and so I shall speak only of the education of the young man who is likely to be fond of engineering.

How are we to detect this fondness in a boy? I think that if the general education of all boys were of the rational kind, which I shall presently describe, there would be no great difficulty; but, as the present academic want of system is likely to continue for some time, it is well to consider things as they are. Mistakes must be made, and the parent who tries during the early years of his offspring to find out by crafty suggestion what line his son is likely to wish to follow will just as probably do evil by commission as the utterly careless parent is likely to do evil by omission. He is like the botanical enthusiast who digs up plants to see how they are getting on. But in my experience the Anglo-

Saxon boy can stand a very great deal of mismanagement without permanent hurt, and it can do no kind of boy any very great harm to try him on engineering for a while. Even R. L. Stephenson, whose father seems to have been very persistent, indeed, in trying to make an engineer of him against his will, does not seem, to a Philistine like myself to have been really hurt as a literary man through his attendance on Fleeming Jenkins' course at Edinburgh —on the contrary, indeed. It may be prejudice, but I have always felt that there is no great public person of whom I have ever read who would not have benefited by the early training which is suitable for an engineer. I am glad to see that Mr. Wells, whose literary fame, great as it is, is still on the increase, distinguishes the salt of the earth, or saviors of society, from the degraded, useless, luxurious, pleasure-loving people doomed to the abyss, by their having had the training of engineers and by their possessing the engineer's methods of thinking.

It may be that there are some boys of great genius to whom all physical science or application of science is hateful. I have been told that this is so, and if so I still think that only gross mismanagement of a youthful nature and have produced such detestation. For such curious persons engineering experience is, of course, quite unsuitable. I call them "curious" because every child's education in very early years is one in the methods of the study of physical science; it is Nature's own method of training, which proceeds successfully until it is interfered with by ignorant teachers who check all power of observation and the natural desire of every boy to find out things for himself. If he asks a question, he is snubbed; if he observes Nature as a loving student, he is said to be lazy and a dunce, and is punished as being neglectful of school work. Unprovided with apparatus, he makes experiments in his own way, and he is said to be destructive and full of mischief. But however much we try to make the wild ass submit to bonds and the unicorn to abide by the crib, however bullied and beaten into the average schoolboy type, I cannot imagine any healthy boy suffering afterwards by part of a course of study suitable for engineers, for all such study must follow Nature's own system of observation and experiment. Well, whether or not a mistake has been

made, I shall assume the boy to be likely to love engineering, and we have to consider how he ought to be prepared for his profession.

I want to say at the outset that I usually care only to speak of the average boy, the boy usually said to be stupid, ninety-five per cent of all boys. Of the boy said to be exceptionally clever I need not speak much. Even if he is pitchforked into works immediately on leaving a bad school, it will not be long before he chooses his own course of study and follows it, whatever course may have been laid down for him by others.

Perhaps I had better state plainly my views as to what general education is best for the average English boy. The public schools of England teach English through Latin, a survival of the time when only special boys were taught at all, and when there was only one language in which people wrote. Now the average boy is also taught Latin, and when he leaves school for the army, or any other pursuit open to average boys, he cannot write a letter, he cannot construct a grammatical sentence, he cannot describe anything he has seen. The public school curriculum is always growing, and it is never subtracted from or rearranged. There is one subject which ordinary schoolmasters can teach well—Latin.* The other usual nine subjects have gradually been added to the curriculum for examination purposes; they are taught in water-tight compartments—or, rather, they are only crammed, and not taught at all. Our school system resembles the ordinary type of old established works, where gradual accretion has produced a higgledy-piggledy set of shops which one looks at with stupefaction, for it is impossible to get business done in them well and promptly, and

*Only one subject—Latin is really educational in our schools. I do not mean that the average boy reads any Latin author after he leaves school, or knows any Latin at all ten years after he leaves school. I do not mean that his Latin helps him even slightly in learning any modern language, for he is always found to be ludicrously ignorant of French or German, even after an elaborate course of instruction in these languages. I do not mean that his Latin helps him in studying English, for he can hardly write a sentence without error. I do not mean that it makes him fond of literature, for of ancient literature or history he never has any knowledge except that Cæsar wrote a book for the third form, and on English literature his mind is a blank. But I do mean that, as the ordinary public-school master is really able to give a boy easy mental exercises through the study of Latin, this subject is in quite a different position from that of the others. If any proof of this statement is wanted, it will be found in the published utterances of all sorts of men—military officers, business

yet it seems impossible to start a reform anywhere. What is wanted is an earthquake or a fire—a good fire—to destroy the whole works and enable the business to be reconstructed on a consistent and simple plan. And for much the same reason our whole public school system ought to be "scrapped." What we want to see is that a boy of fifteen shall be fond of reading, shall be able to compute, and shall have some knowledge of natural science; or, to put it in another way, that he shall have had mental training in the study of his own language, in the experimental study of mathematics, and in the methods of the student of natural science. Such a boy is fit to begin any ordinary profession, and whether he is to enter the church, or take up medicine or surgery, or become a soldier, every boy ought to have this kind of training. When I have advocated this kind of education in the past I have usually been told that I was thinking only of boys who intend to be engineers; that it was a specialized kind of instruction. But this is very untrue. Let me quote from the recommendations of the 1902 Military Education Committee (Report, p. 5):

"The fifth subject which may be considered as an essential part of a sound general education is experimental science; that is to say, the science of physics and chemistry treated experimentally. As a means of mental training, and also viewed as useful knowledge, this may be considered a necessary part of the intellectual equipment of every educated man, and especially so of the officer, whose profession in all its branches is daily becoming more and more dependent on science." When statements of this kind have been made by some of us in the past, nobody has paid much

men, lawyers, men of science, and others—who, confessedly ignorant of "the tongues," get into a state of rapture over their school experiences and the efficiency of Latin as a means of education. All this comes from the fact, which schoolboys are sharp enough to observe, that English schoolmasters can teach Latin well, and they do not take much interest in teaching anything else. It is a power inherited from the Middle Ages, when there really was a simple system of education. I ask for a return to simplicity of system. English (the King's English; I exclude Johnsonese) is probably the richest, the most complex language, the one most worthy of philologic study; English literature is certainly more valuable than any ancient or modern literature of any one other country, yet admiration for it among learned Englishmen is wonderfully mixed with patronage and even contempt. At present, is there one man who can teach English as Latin is taught by nearly every master of every school? Just imagine that English could be so taught by teachers capable of rising to the level of our literature!

attention; but I beg you to observe that the Headmaster of Eton and the Headmaster of St. Paul's School are two of the members of the important committee who signed this recommendation, and it is impossible to ignore it. Last year, for the first time, the president of the Royal Society made a statement of much the same kind, only stronger, in his annual address. I am glad to see that the real value of education in physical science is now appreciated; that mere knowledge of scientific facts is known to be unimportant compared with the production of certain habits of thought and action which the methods of scientific study usually produce.

As to English, the committee say: "They have no hesitation in insisting that a knowledge of English, as tested by composition, together with an acquaintance with the main facts of the history and geography of the British empire, ought in future to hold the *first* place in the examination and to be exacted from all candidates." The italics are mine. It will be noticed that they say nothing about the practical impossibility of obtaining teachers. As to mathematics, the committee say: "It is of almost equal importance that every officer should have a thorough grounding in the elementary part of mathematics. But they think that elementary mechanics and geometrical drawing, which under the name of practical geometry is now often used as an introduction to theoretical instruction, should be added to this part of the examination, so as to ensure that at this stage of instruction the practical application of mathematics may not be left out of sight." As Sir Hugh Evans would have said, "It is a very discretion answer—the meaning is good"; but I would that the committee had condemned abstract mathematics for these army candidates altogether.

This report appears in good time. It would be well if committees would sit and take evidence as to the education of men in the other professions entered by our average boys. It is likely that when an authoritative report is prepared on the want of education of clergymen, for example, exactly the same statements will be made in regard to the general education which ought to precede the technical training; but perhaps a reference may be made in the report to the importance of a study of geology and biology as well as physical science. Think of the clergyman being able to meet his scientific enemies in the gate!

Thanks mainly to the efforts of a British Association Committee, really good teaching of experimental science is now being introduced into all public schools, in spite of most persistent opposition wearing an appearance of friendliness. In consequence, too, of the appointment of a British Association Committee last year, at what might be called the psychological moment, a great reform has already begun in the teaching of mathematics. Even in the regulations for the Oxford Locals for 1903 Euclid is repudiated. It seems probable that at the end of another five years no average boy of fifteen years of age will have been compelled to attempt any abstract reasoning about things of which he knows nothing; he will be versed in experimental mathematics, which he may or may not call mensuration; he will use logarithms, and mere multiplication and division will be a joy to him; he will have a working power with algebra and sines and cosines; he will be able to tackle at once any curious new problem which can be solved by squared paper; and he will have no fear of the symbols of the infinitesimal calculus. When I insist that a boy ought to be able to compute, this is the sort of computation that I mean. Four years hence it will be called "elementary mathematics." Four years ago it was an unorthodox subject called "practical mathematics," but it is establishing itself in every polytechnic and technical college and evening or day science-school in the country. Several times I have been informed that on starting an evening class, when plans have been made for a possible attendance of ten or twenty students, the actual attendance has been 200 or 300. Pupils may come for one or two nights to a class on academic mathematics, but then stay away for ever; a class in practical mathematics maintains its large numbers to the end of the winter.*

Hitherto the average boy has been taught mathematics and mechanics as if he were going to be a Newton or a Laplace; he learned nothing and became stupid. I am sorry to say that the teaching of mechanics and mechanical engineering through experiment is comparatively unknown. Cambridge writers and other

*To many men it will seem absurd that a real working knowledge of what is usually called higher mathematics, accompanied by mental training, can be given to the average boy. In the same way it seemed absurd 500 years ago that power to read and write and cipher could be given to everybody. These general beliefs of ours are very wonderful.

writers of books on experimental mechanics are unfortunately ignorant of engineering. University courses on engineering—with one splendid exception, under Professor Ewing at Cambridge—assume that undergraduates are taught their mechanics as a logical development of one or two axioms; whereas in many technical schools under the Science and Art Department apprentices go through a wonderfully good laboratory course in mechanical engineering. We really want to give only a few fundamental ideas about momentum and the transformations of energy and the properties of materials, and to give them from so many points of view that they become part of a student's mental machinery, so that he uses them continually. Instead of giving a hundred labor-saving rules which must be forgotten, we ought to give the one or two ideas which a man's common sense will enable him to apply to any problem whatsoever and cannot be forgotten. A boy of good mathematical attainments may build on this experimental knowledge afterwards a superstructure more elaborate than Rankine or Kelvin or Maxwell ever dreamed of as being possible. Every boy will build some superstructure of his own.

I must not dwell any longer on the three essential parts of a good general education which lead to the three powers which all boys of fifteen ought to possess; power to use books and to enjoy reading; power to use mathematics and to enjoy its use; power to study Nature sympathetically. English board school boys who go to evening classes in many technical schools after they become apprentices are really obtaining this kind of education. The Scotch Education Board is trying to give it to all boys in primary and secondary schools. It will, I fear, be some time before the sons of well-to-do parents in England have a chance of obtaining it.

PHYSIOLOGY AS A SCIENCE STUDY IN THE HIGH SCHOOL.*

BY GRACE F. ELLIS,

Instructor in Biology, Grand Rapids (Mich.) Central High School.

Physiology was the first of the life sciences to have a place in the curricula of the schools, but in its introduction, and for many years thereafter, it bore little resemblance to a science as we now understand the term. It was a textbook subject, hated by the unhappy teacher to whom it was assigned and avoided by the pupils whenever possible.

At a later day it consisted chiefly of certain dicta concerning the effects of alcohol on the different systems of the human body. It was seldom or never illustrated, for illustration to the lay mind savored of the handling of "inwards," a thing to be religiously avoided.

It is small wonder then that this most important of the sciences has fallen into disrepute among educators themselves, and receives but a scanty and grudging recognition in the assignment of subjects.

In the face of all this I do not feel inclined to modify the statement I have made above, that it is the most important science in the curriculum. To it every other science, properly arranged, should lead; to it, also, the pupil should bring not only the facts of botany, zoölogy, chemistry and physics, but the feeling that here he is to learn how to make the most of himself—the best use of this wonderful machine which holds us each, and through which, and by means of which, we make the world better by our having lived.

The optimum and logical preparation for physiology would be that botany, zoölogy, chemistry and physics should precede it. This might be accomplished by placing it in the last half of the twelfth year. Parenthetically, let me say that we expect to offer such a course after this year, and that physiology is also taught

*Prepared for the Conference of the Biological Section of the Michigan Schoolmasters' Club, held at Ann Arbor, Mich., March 28 and 29, 1902.

in connection with zoölogy during a year's course in the latter subject. It is a part of the zoölogy, not a subject taken up at the end of work on vertebrates, but introduced by the study of foods, when we reached a point in invertebrate work where that could profitably be handled; by a farther study of glands and digestion, when glands and their functions became of interest in the zoölogy and by a study of motor organs (amœboid cells, ciliated cells and muscles), when in worms and molluscs, muscular activity was noticeable.

Study of circulatory systems is made when any animal large enough to have a distinct system for the circulation of blood, is taken up in the laboratory. Respiration and excretion follow naturally.

The study of the nervous system will be taken up in connection with work on vertebrates, beginning with functions of nerves and ganglia when the class finishes the work on arthropoda. The skeleton in this course will be the last thing to be considered, instead of, as usual, the first thing, and in connection with it will be some work on muscles. This work will be illustrated by the use of the "joint apparatus" devised by Dr. Fitz, of Harvard.

This outline is not primarily of physiology, but only of that treatment of the subject which it seems to me ought to be included in any course in zoölogy, unless the zoölogy has been preceded by physiology, or is to be followed by it.

Where physiology is to be studied by itself, the first thing to be considered in outlining the work is where it is to come in the high-school course. I have indicated what I consider its proper place. Others will undoubtedly think differently, but, at any rate, all will agree that if it is not preceded by some chemistry and physics, it must be illustrated by simple experiments in order to make it comprehensible by the student.

The teacher of physiology may talk of oxidation and digestion, of proteids in the food, calcium phosphate in the bones, of carbon dioxide and nitrogen in the air, but unless he and his pupils understand the elements of chemistry, unless they see and handle the things they talk about, they might as well talk of Greek verbs. With the microscope he may show them cells, but he can-

not go further—unless he is a chemist—and show them that the whole complex animal body has been built up of three invisible gases and carbon.

In this I find the starting point for my work; in the laboratory, without any textbook and only a sheet of directions as to processes, and questions as to results, the learner finds out for himself something about the substances which enter into the composition of his own body.

This introductory work is followed by a set of very simple experiments on acids and alkalies, and the whole by a sharp quiz which shall "fix" the results. Then the study of food can be introduced with experiments to show the reactions of various tests for starches, sugars, proteids, fats and minerals. A few foods may be tested to show how many and what food principles they contain, these studies to be followed by a series of experiments on digestion in which test tubes, containing foods and digestive fluids, are suspended in a water bath with a chemical thermometer and kept at a temperature of 99° F.

I like to precede the study of the alimentary canal by a dissection of some mammal, in which peristaltic action, the divisions of the canal, locations and connections of glands are pointed out. Students are sometimes required to make a hasty sketch of the dissection and compare with location of the same parts in the manikin. While the work on foods is going on in the laboratory in the class-room we discuss work and energy, uses of foods, etc., and oxidation and combustion are illustrated.

The alimentary canal and digestion are then studied in detail. The former illustrated by slides to show structure of stomach, intestines, glands, etc., and the latter by experiments on fat-digestion (emulsions and soaps) and absorption. A bit of sausage skin tied over the flaring end of a test tube whose closed end is chipped off will give good results as to absorption of digested and undigested proteids. In food study, as in many other parts of my laboratory work, I am indebted to Peabody's "Laboratory Manual" for suggestions.

We follow digestion with circulation. When it is possible we have in the laboratory three jars of blood, the whipped, coagulated, and fibrin from the first, with a microscopic study of frog's

and human blood. This gives us an impetus; aided by study of circulation in the frog's foot—or, better still, in the tadpole's tail or the caudal fin of a small fish, the interest grows until it is positive excitement when we study the beating heart of a frog or turtle, and dissect the calf's heart from the market.

Let me say in passing that careful counting and timing with a watch will show the comparative length of work and rest periods for the heart.

Difference in arterial and venous currents, pulse, arterial spurting and slowing of blood flow in capillaries are all illustrated in a simple piece of apparatus consisting of glass Y-tubes and rubber tubing, the construction of which is explained in Macy's Physiology.

At the end of this work, along with quiz and laboratory notes, I require each pupil to put on the board or paper his notion of the structure of the heart in a diagram that shall show chambers, valves, blood vessels, etc.

Respiration and excretion are next in order. So essential does the study of lung capacity seem to me that I have devised an apparatus for its measurement, a figure of which was published in SCHOOL SCIENCE, Vol. I., No. 7, p. 372. Accompanying it is an outline of the questions each pupil answers in regard to it. When the work is handed in, a personal talk with each pupil emphasizing the points made is very helpful. Students take pride in a good lung record and often take pains to improve it, taking occasional measurements through the year.

Dissection of kidney and slides of sections through the skin sufficiently illustrate the functions of excretion.

The students do not open their textbooks to study the nervous system until they have made a series of simple experiments on frogs to get an idea of the use of nerves and ganglia. In this work, especially, should care be taken that the learner distinguishes in the experiments the results he observes from the inferences drawn from these results.

If we should study the growth of civilization we should find it had been brought about by the mental operations of independent observation, experiment, classification, deduction and generalization. These lie at the bottom of all scientific study, all scientific

knowledge. The most profitable science teaching is that which teaches a pupil proper observation and experiment.

When physiology is challenged at the threshold of the high school—what do you bring that we should admit you here?—it must be able to answer and to prove with its kindred sciences that it brings the power of independent thought which is the greatest object to be desired among the masses of the people in present or future time.

Speaking of the moral factor in education at the N. E. A. last summer, President Faunce, of Brown University, said "Over every true school might well be inscribed the sentence which we find in Genesis: 'Let us make man.' Over the entrance to its scientific laboratories may be written: 'Let us help man to make the most of himself.' He who teaches at all follows in the wake of the Creator. He who teaches biology knows that the handful of dust which composes man worked its toil—some way from lowest protozoan to highest mammal, from mammal to man, and through an epitome of race history he must develop afresh the powers of each student.

"With earth's first clay they did the last man knead,
And then of the last harvest sowed the seed,
And the first morning of Creation wrote
What the last dawn of destiny shall read."

Physiology, hygiene and sanitation should, in the mind of the teacher, be the interpretation of the simple physiology of our course of study; for a knowledge of physiology is required in life, far beyond the ground covered by a course of lectures or an elementary textbook.

It is desirable that there be a widespread understanding of the nature of contagious diseases in order that the action of medical boards and boards of health may have a meaning in the minds of the public at large. The creation of such an understanding seems to me an important duty of the public schools.

Some of the most important questions we have to face in our country today arise from ignorance or reckless disregard of the fundamental facts of human existence. The unsanitary condition of the slums, the restriction of disease, the essential facts of contagion and disinfection, the conception of bacteria, infec-

tion and prophylactic measures, the children with neglected eyes and teeth and bodies, social evils and wrongs, from customs contrary to physiological facts—all these must be remedied by the training of young men and women in our laboratories, who shall save society. We can prevent it from becoming the prey of the evil only by producing the wise and good, who shall overcome the evil.

That righteousness tendeth to life, and the wages of sin is death, is not only morality, but physiology. Correct action is dependent upon correct thinking. The more familiar a man is with the laws of nature, the more he will obey them and work in harmony with them, to the benefit of himself and his fellows.

Let me quote once more from President Faunce: "The study of science itself has done much to promote exactness of observation and honesty of report. It has set before us as the model student of the nineteenth century, Charles Darwin, of whom it has been said that in all his voluminous writings not an instance can be found of a fact misstated or consciously perverted. It has given our students patience in study and taught them the greatness of creation."

And as to physiology Huxley said long ago: "There is a very convenient and handy animal which everybody has at hand, and that is himself. * * * Hence the general truths of anatomy and physiology can be taught to young people in a very real fashion by dealing with the broad facts of human structure. * * * So that, in my judgment, the best form of biology for teaching to very young people is elementary human physiology."

PUPIN'S INVENTION.

BY J. W. PATTERSON, JR.

Junior Professor of Electrical Engineering, University of Michigan.

Much interest has been shown by the scientific world in Professor Pupin's invention of the loaded telephone line, an invention which has vastly improved the transmission of speech over long distances. I may briefly recall the conditions present in the telephone circuit. The line has, sent into it, a certain periodically varying current, called a complex harmonic current. Very little of this current reaches the receiving apparatus at the distant end, in general less than one per cent on long lines; the rest is abstracted by the charging of the line and held back by the line's resistance. If this resistance were absent the charge waves would be transmitted without loss. So the electrostatic capacity of the circuit, in conjunction with the resistance, is an objectionable feature. If it were possible to suppress one or the other, long distance telephony would be possible to any distance. As it appears to be out of the question to suppress either, some counter effect must be sought. Now it is well known that self-inductance combats capacity, and so increased inductance is the most evident remedy. But how to apply it was the puzzle. It was early suggested by some to put self-inductance in parallel with the capacity, but without good effect; others have tried large inductances in series, which also resulted in failure to produce the desired effect. The theoretical problem was so complex that no one before Pupin had solved it. Consequently their experiments did not take the proper form. Professor Pupin first solved the theoretical problem and followed with experiments performed under favorable conditions.

Pupin introduced into the line wire many small equal and equally spaced inductances. The introduction of more self-inductance demands more energy on the line to transmit the same current; but this is no detriment, as the increase of energy hinders the alternation of the current from wave to wave along the line.

*Read before the Physics Conference of the Michigan Schoolmasters' Club, March 28, 1902.

Mathematically a telephone line is like a vibrating cord, and, though reasoning by analogy is exceedingly dangerous, yet it may be very helpful when the mathematical parallelism is close, provided it is checked by experiment. Pupin illustrates the telephone problem by means of the vibrating string. Suppose a very long, light, elastic string, which has no stiffness, to vibrate under the influence of simple harmonic impulses communicated to one end. If the string is long, waves will be produced which, because of air and other friction, have smaller and smaller amplitudes as they run along the cord from the source. With short strings the phenomenon of stationary waves is produced, but in the case considered they are not present to any considerable extent. Had the string more mass in the same cross-section, the damping of the waves would be less. Suppose, as a substitute for more uniformly distributed mass, we load the string at frequent intervals by means of many equal and equally spaced masses, we may approximate the uniformly loaded string. If, however, we apply the whole load at one point or divide it among a few points, we will defeat our object, as the large mass will have a tendency to anchor the string and to reflect the waves and not to transmit them. Thus we may explain the failure of large inductances to improve telephony, when the inductances are localized at a few points. Calling a whole wave length 2π, if the loads are at intervals ϕ, so small that $\sin \frac{1}{2}\phi$ differs little from $\frac{1}{2}\phi$ (say less than 2 per cent), then the wave is well transmitted.

In the telephone circuit we deal with complex harmonic waves which consist of a combination of simple harmonic waves each of the form $i = I\ e^{-bx} \cos(pt - Bx)$ in which i is the current at the distance x from the transmitter at the time t, and I is the maximum current at the origin. The constants b, p and B have to do with the force and velocity of propagation of the wave; the constant b is the attenuation constant and has for its value

$$b = \sqrt{\frac{pc}{2}\left(\sqrt{p^2 L^2 + R^2} - p\ L\right)},$$

in the case of uniformly distributed resistance R, capacity c and inductance L. If L is small in comparison with R this reduces to

$b=\sqrt{\frac{pcK}{2}}$ (nearly); and if L is large in comparison with K, $b=\frac{K}{2}\sqrt{\frac{c}{L}}$ (nearly). In the former case higher frequency (larger values of p) causes more attenuation; in the latter case the attenuation is independent of the frequency within the limits of the approximation, and large values of L cause reduced attenuation. Both of these properties are favorable to good telephony; for small attenuation means loudness, and uniform attenuation for all frequencies means faithful reproduction of the quality of the voice.

To illustrate the application of the invention we may take a line 250 miles long without the loading coils; suppose L=0, R=9 ohms, C=0.074 m. f. per mile, b=0.000004. This small value of b (0.000004) would make it impossible to hear anything over the line. If to this line we add loading coils having a resistance of 9 ohms extra per mile (in all R=18 ohms) and an inductance of 0.056 henry per mile, we obtain b=0.025, in which case speech will be good.

I understand that the Bell Telephone Co. (Am. Tel. & Tel. Co.), to whom Professor Pupin has sold his invention for a princely sum, is now experimenting on a line 6,000 miles long, obtained by using in series three New York-Chicago lines, which is equivalent to a metallic circuit between cities 3,000 miles apart. The line is said to talk well and it appears quite probable that there will be no difficulty in using a line from New York to the Pacific coast. One big advantage from the commercial standpoint is due to the fact that a New York-Chicago line, which now costs $250,000 for copper alone, may be built with loading coils for less than half that amount. If the saving of capital is as great as expected, the price paid Professor Pupin will prove quite moderate.

ELEMENTS OF AGRICULTURE IN THE HIGH-SCHOOL BOTANY COURSE.

BY RICHARD RUNKE.

Science Teacher, Merrill (Wis.) High School.

It will no doubt be admitted by all that any change which makes more practical and adds practical value to the botany course is in itself a desirable change. The high-school botany work is too often regarded as a pleasant but quite useless diversion, as a study which may be attractive but of little if any practical value. If such a change as mentioned can be made without detracting in any way from the value of botany as a systematic, disciplinary science the improvement should be welcome. Further than this, if the addition increases the disciplinary value of the study and makes it more valuable the change must be not only desirable but necessary.

Our high-school botany courses always have lacked and do lack direct, practical application. Botany has progressed much in late years. It has moved forward from a theoretical, textbook study to one which requires concrete illustration and application in the laboratory and the field. We should now be ready to proceed still farther and make our laboratory and field work of an intensely useful and practical nature. Of what use are the theoretical, thin-as-air, dry-as-dust conceptions of the textbook? Of little use, unless we apply them. Of what use then, is our laboratory and field work unless we can see its business application, its practical use, its effectual benficial results? Who would think of teaching geography without calling attention to its economic aspect? We no longer teach grammar as a set of dead rules which must be memorized. We apply them and ask for results. In history we demand cause and effect and attempt to deduce rules for future guidance. In botany, therefore, we should strive to give agriculture its true place and thereby modify botany as we have already modified the studies named.

Is it not more than passing strange that many botany courses should ignore the commonest vegetables, fruits, cereals, and trees, and their cultivation and propagation, only to pursue strange gods in stranger places? Has not every pupil a right to demand that

his instruction embrace those things which are abundant in the garden and on the farm? Those things which he meets and sees most often on the farm and in the market? The absence of the elements of agriculture can be accounted for only because of the following reasons: In the first place, our botany teachers are not ready to give the proper instruction because they themselves have received no better nor different training. The second reason embraces the first and gives the real explanation. It is that agriculture has been a despised occupation, one considered much inferior to any other respectable occupation, and inferior to some not respectable. It is generally supposed that any person, no matter how ignorant, can run a farm. That it requires no skill, much less any science, to do so. To be a mere farmer implies contempt instead of implying, as it should, that of all the children of nature the farmer resides closest to his parent. It must be made plain that of all known occupations agriculture requires more real science than any other. The mad rush for city occupations sufficiently attests that agriculture is losing ground in popular opinion. The high-school should do something to stem the tide. It must help to turn the tide the other way.

The demand of every other occupation, profession or trade is reflected in our high-school work. Witness the introduction of bookkeeping, of cooking, of commercial arithmetic, of shorthand, of manual training, of the theory and art of teaching. Does not agriculture, therefore, which is equal in economic importance to all others combined, deserve at least equal recognition? It should certainly receive at least partial recognition in a study where it rightfully belongs, namely botany. Instead of "enriching" the high-school curriculum with work which fails to enrich, let us improve those studies which we have.

Let it not be supposed that this change means a revolution. It means merely that we should modify our courses somewhat. The introduction of the multitude of concrete illustrations and applications which agriculture furnishes will make botany easier to teach, more interesting as a study and less impractical than it now is. Botany will gain in regard by the change, while agriculture will receive no more than just consideraation.

It may be asked by some, "What do you mean by the elements

of agriculture?" It will be seen by the following fragmentary suggestions that no violent change is suggested. Merely a natural unfolding and progress of the study is intended.

Farm losses by parasitic fungi.
Ways in which they injure.
Means of preventing their ravages.
Insect foes and friends of fruits, trees, and vegetables.
Preventatives and remedies. Use and value of spraying.
Work of friendly and unfriendly bacteria.
How to aid the one and destroy the other.
Time and conditions for seeding and planting.
Qualities and grades of seed and selection thereof.
Propagation by cutting, runners, grafts (both stem and root).
Hybrids, varieties, "sports," heredity, environment.
Plant protection in winter, cultivation in summer.
Fodder and its preservation. Silage and silos.
Weeds, kinds, extirpation of.
Soil conditions, plowing, harrowing, tilth in general.
Crop foods, fertility, necessity for rotation.

This list might be extended, but if our high schools will introduce or emphasize the above points a step in the right direction will have been taken.

A "TUMBLER GALVANOMETER."

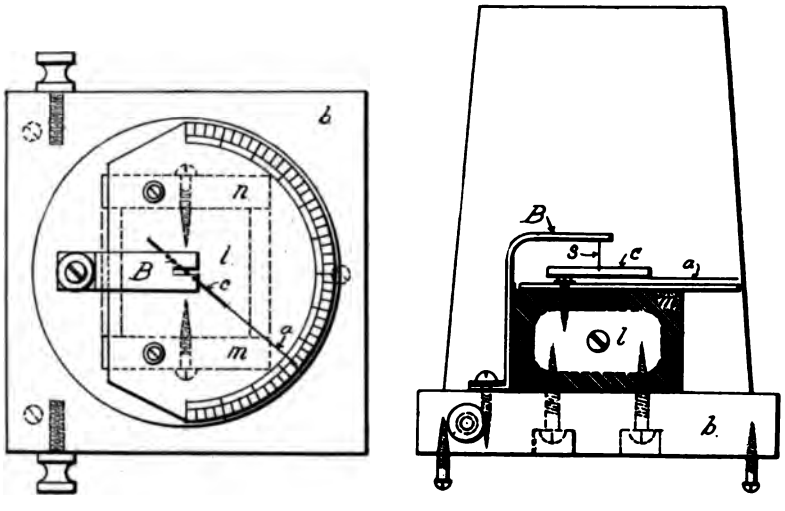
BY E. C. WOODRUFF.

Instructor in Physics, La Grange (Ill.) High School.

The instrument herein described has competed during the past year with ten other forms of galvanometers in the writer's laboratory. These ten forms, home-made and otherwise, included instruments made after practically all the designs suggested in the different laboratory manuals; besides several more elaborate instruments. Still for high-school laboratory purposes, except for induction and bridge work, they all left some things to be desired. The design here offered grew out of attempts to eliminate these undesirable, and sometimes provoking features. It has proved more generally useful than the others in the following respects: The materials and operations involved in construction and repair are of the simplest. There is the mechanical steadiness of a pivoted compass-needle without its frictional irregularities and tendency

to stick. There is sufficient sensitiveness without the tendency of needles suspended by long fibers to be mechanically disturbed. The details of construction are all in sight so that the pupil grasps them at once. Wide changes in sensitiveness are easily obtained. Magnetic control is very simply arranged. The action of the needle is rapid and the steady deflection can be found quickly, thus saving time for the pupil and energy for the battery. The size is a desirable one, the instrument being covered with a tumbler.

The drawings show a plan and an elevation. The dimensions can be determined from that of the base, 9 cm. x 9 cm. The base *b*,



and the three pieces *l*, *m*, and *n*, that form the frame for the coil, are of hardwood fastened together with brass screws. The coil contains about 100 turns of No. 22 double cotton-covered copper wire, filling the shaded part in Fig. 1. The ends of the wire are brought out through the sides of the frame and then down through the base so as to make connections with the binding posts from below. The wire is sufficiently in sight for the pupil to readily trace the direction of the current through the coil. The cardboard dial is fastened to the sides of the frame *n* and *m*. *B* is of 1-16 inch sheet brass with a saw slit in the upper end so that the suspension can be easily placed to suit. The needle, *c*, has

a length a little less than the width of the coil. This keeps it in a more uniform field. Aluminum wire, *a*, wound around the ends of the needle serves as a counterpoise and a pointer. The suspension, *s*, is made by untwisting a silk thread and separating a strand equal to half a dozen fibers, or less. Though the free length of the fibers is but ½ cm., there is plenty of sensitiveness with a great gain in mechanical steadiness.

For some experiments a shunt is desirable; *e. g.*, such an experiment as connecting batteries in series and in parallel and comparing the deflections with different resistances in circuit. The instrument can be adapted to lecture-table work by bending the pointer at a right angle at the end and bringing it down in front of a suitable scale.

The galvanometer will stand very hard usage for one of its sensitiveness. Twice during the past summer it has been wrapped in a newspaper and sent 300 miles in a heavily loaded trunk, each time coming out of the ordeal all ready for use.

SOME IMPROVEMENTS IN APPARATUS FOR EXPERIMENTS IN ACCELERATED MOTION.

BY E. E. BURNS,

Instructor in Physics and Chemistry, DeKalb (Ill.) High School.

In School Science (Vol. I., p. 202) a new form of the Atwood machine is described by Mr. H. W. Hawkes. This machine appears to me to be the best yet devised for experiments in accelerated motion. Its cost, however, will prevent its immediate adoption in some schools. These schools must be content, for a time, at least, with a simpler form of the experiment. I believe that I have succeeded in eliminating from the inclined plane form of the accelerated motion experiment the sources of error pointed out by Mr. Hawkes. I believe, moreover, that by direct experimental determination of velocity the pupils will obtain a clearer conception of the meaning of velocity than if this quantity is determined by a process of calculation.

Before taking up the experiment in accelerated motion, the pupil has learned that the velocity of a moving body at a given

instant is the distance the body would move during the next unit of time if the rate of motion were to remain unchanged. This will be the condition if, at the given instant, the body starts to move on a horizontal plane where the friction is too small to retard the motion perceptibly. The use of the horizontal plane in this experiment is due to Prof. Snow, of the University of Wisconsin. I have only adapted the experiment to the laboratory.

The inclined track is made by nailing strips of zinc to the sides of a board sixteen feet long and one inch thick, so that the strips project half an inch beyond the edge of the board. The horizontal track is made in the same way, except that one end of the board is beveled and the zinc strips are not fastened at the beveled end. This beveled end is fitted between the zinc strips of the inclined track and the zinc strips of the horizontal track are held in place by means of a table clamp and two strips of wood. A pendulum indicating seconds by means of a telegraph sounder is used.

The error due to the difficulty in starting the ball at the instant of the tick is eliminated in the following manner: A piece of platinum wire fastened to the arm of the telegraph sounder is bent at right angles and dips into a cup of mercury. Through this cup of mercury connection is made with a current which excites an electromagnet at the upper end of the track. A steel sphere one and one-half inches in diameter is held in place by the electromagnet. When the switch of the sounder is closed the first tick breaks the contact at the mercury cup and releases the sphere. To insure the instant release of the sphere a piece of paper should be placed between it and the magnet.

The difficulty of perceiving the coincidence of two dissimilar sensations is obviated by using a second telegraph sounder. This sounder and battery are connected by means of flexible wire cord with a lead push-button which is fastened to a block of wood and held in the groove. I found that this device added greatly to the accuracy of the results, showing that the coincidence of two sensations can be perceived much more accurately when the sensations are similar. The reason for making the push-button of lead is that the circuit remains closed when the ball strikes and only

one tick is heard. By means of a rubber band to deaden the sound the double click of the pendulum sounder is reduced to a single click.

The results obtained with this apparatus are not so accurate as those obtained with the Hawkes-Atwood machine, but they are sufficiently accurate to illustrate the laws of accelerated motion, and, so far as my experience goes, this is more than can be said of the old form of the inclined plane experiment. The following results were obtained by my pupils after the improvements were made in the apparatus:

	d	d	d	v	v
	$t = 1$.	$t = 2$.	$t = 3$.	$t = 1$.	$t = 2$.
	29.7	124.6	276.7	64.8	118.4
	29.3	121.9	276.8	58.5	117.0
	30.3	117.0	253.0	61.8	121.5
	31.5	126.6	265.0	65.3	124.1
	31.5	127.9	279.6	65.7	122.2
Means.	30.46	123.6	270.2	63.2	120.6

These results were obtained by ten pupils working in twos, and are all of the results that I have to show, as the improvements were made somewhat late in the year. It will be seen that the velocities which were determined experimentally agree quite well with the theoretical values.

ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY

BY GEORGE W. MYERS.

(*Concluded from page 228.*)

Experiment XL.

To draw the celestial equator at a given epoch.

This can be best done by means of the spherical blackboard fitted with the precessional circles.

Set the pole pins into the sockets corresponding to the epoch. Then with crayon, or camel's-hair brush moistened with water-color, held against the $0°$ of the meridian and touching the globe,

roll the globe once around. If a number of equators for different epochs are thus drawn, the significance of the precession of the equinox becomes obvious.

Draw the equators for 500 B. C.; 10000 B. C.; and for 5000 A. D.

Experiment XLI.

Find the right ascension and declination of stars for any epoch.

Set the pole pins to the given epoch as before, and bringing the star under the brass meridian, *M*, the declination may be read off directly.

For right ascensions elevate the celestial pole at an angle of 90° to the horizon. The horizon will then indicate the position of the celestial equator for that epoch. Now bring the poles of the ecliptic under the meridian, the north ecliptic pole being south of the north celestial pole. The point on the ecliptic coinciding with the east point of the horizon will then denote the first of Aries for the epoch. By means of the strip, *S*, read off along the horizon the number of degrees from the first of Aries to the brass meridian, *when the star has been brought under this meridian.* Dividing the number of degrees by 15 will give the right ascension in hours, minutes, and seconds.

(a) Find for the epochs 1000 A. D. and 10000 B. C. the right ascensions and declinations of the following stars: Arcturus, Aldebaran, Sirius, Procyon, Canopus.

Experiment XLII.

To find the azimuths of stars at rising or setting for any required epoch.

Set the globe as before and rectify it for the latitude of the place of observation. Then bring the required stars to the eastern or western horizon according as the rising or setting azimuth is wanted. Read off the azimuth along the wooden horizon.

(a) Determine the azimuth at Thebes (Lat. 25° 40′ N.) of the Pleiades, Sirius, and Gamma Draconis and other stars, for 1000 B. C. and 3000 B. C.

(b) Repeat the above measures for the latitude of Chicago (41° 50′).

Experiment XLIII.

To describe an ellipse.

The paths, or orbits as they are called, of all the planets are ellipses, differing not materially from circles. The curve known as the ellipse may be described on paper by tying the two ends of a thread, or string, to pins stuck at the points S and E the distance between which is less than the length of the thread, and then placing the pencil point at some intermediate point of the thread, keeping both ends taut, slide the pencil along over the paper and the mark produced will be an ellipse.

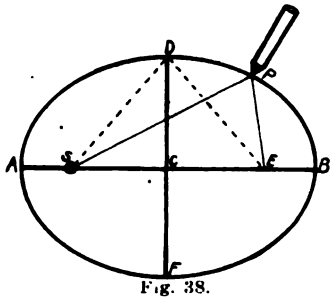


Fig. 38.

The line AB drawn through the pin-holes until it touches the curve is called the major axis, and half of it, AC or BC the semi-major axis, DF perpendicular to AB at its middle point, C, is the minor axis, and half of it, CF or CD, the semi-minor axis.

Notice that AB is the length of the thread, and that when the pencil is at D, SD and DE are equal, and each is equal to half of AB.

The semi-major axis is usually denoted by a, and the semi-minor by b. SC, or CB, is called the linear eccentricity, and $SC \div AC$ the eccentricity, and is designated by c.

Since SCD is the right triangle and $SD = a$, we have—

$$e = \frac{\sqrt{a^2 - b^2}}{a}; \quad SC = ae = \sqrt{a^2 - b^2}; \quad \frac{b^2}{a^2} = 1 - e^2; \quad b^2 = a^2(1 - e^2)$$

Work out these equations.

The planets with their symbols, orbital eccentricities, and semi-major axes are here tabulated:

PLANET	SYMBOL	ECCENTRICITY *e*	SEMI-MAJOR AXIS *a*
Mercury	☿ (Wand)	0.21	36 million miles
Venus	♀ (Mirror)	.01	67 " "
Earth.....	⊕ (World, with Meridian and Equator)	.02	93 " "
Mars.....	♂ (Shield and spear) ..	.09	141 " "
Jupiter	♃ (Old Greek *Z*).....	.05	483 " "
Saturn	♄ (Sickle).....	.06	886 " "
Uranus	♅ (World)	.05	1782 " "
Neptune	♆ (Trident)	.01	2792 " "

Work out the values of *b* for each of these orbits.

The semi-major axis of the moon's orbit is 239,000 miles and its orbital eccentricity, *e*, is 0.055. Find *b* for the moon's orbit.

Draw ellipses to represent the orbits of the moon, of Mercury and of Mars and note how nearly circles they are.

Note also that the nearer the pins (the foci) are to the center of the ellipses the smaller *e* is and the nearer the ellipse is a circle.

Metrology.

HOW UNCLE SAM GOT A DECIMAL COINAGE.

BY DR. WILLIAM H. SEAMAN.

(*Concluded from page 236*)

As the colonists imported themselves into the country, so they imported their arithmetics at first, and in Wingate's arithmetic, printed at London in 1735, we have the foundations of weights, measures and money. It would be a good thing if some of this information were retained in the arithmetics of the present day, so that the rising generation would have some idea of the beginnings of things, instead of being left to suppose they always were as they now are.

This little book, a copy of which may be found in the library of the Bureau of Education, tells us that "The smallest weight used in England is the grain, the weight of a grain of wheat, well dried and gathered out of the middle of the ear, of which 32 make another weight called a pennyweight, and 20 pennyweights make one ounce Troy. This was according to the statutes of Henry III., chapter 51, in 1236, and this weight regulated the money of England for about 200 years before the conquest. Osbright, a Saxon, being then king of England, caused an ounce Troy of silver to be divided into 20 pieces called pence. This was the value of an ounce of silver at that time. But in the time of Henry VI. 30 pieces were made from the ounce; Edward IV. made 40, and Henry VIII. increased it to 45, and finally Queen Elizabeth made the ounce into 60 pence, where it now stands. In the same library may be found Pike's arithmetic containing whole pages of tables for converting the various moneys in use in the colonies in 1808 into equivalent values, and also containing the Act of Congress, passed July 6, 1785, establishing the federal currency, according to which the dollar shall contain of fine silver 375.64 grains. In 1786 an act was passed that the mint price of a pound Troy of silver 11-12 fine shall be 9 dollars, 9 dimes and

*Communications for the Department of Metrology should be sent to Rufus P. Williams, Cambridge, Mass.

2 cents. A brief comparison of the tables of monies about a century old in this arithmetic, with the corresponding tables now in use occupying hardly one tenth the space, is one of the strongest possible arguments in favor of the decimal system for all measures.

The earliest coin known to have been made for the British colonies was a brass shilling struck in 1612 by the Virginia company on the Bermuda islands, then known as the Summer islands. The next was the pine tree shilling, authorized by the General Court of Massachusetts in 1652. The mint was built on land of John Hull, who was made mint master. The first coins made were only planchets with the letters N. E. on one side, and XIId, VId, and IIId on the other, only these three denominations being authorized. October 19 a second act was passed, by virtue of which the figure of a pine tree was put on one side in a ring with the words "Massachusetts in." and on the other side the date and value. This coinage was continued till 1686, but it does not appear that the date was ever changed. The office of mint master seems to have been very profitable, and when John Hull's daughter was married the big scales were brought in and the bride put on one pan, while the pine tree shillings were poured into the other till the buxom girl kicked the beam, and thus determined the amount of her dowry.

Both George I and George III had brass and copper coins struck in England for use in the colonies, but no considerable amount ever went into circulation. At the beginning of the Revolution, and down to the adoption of the Federal Constitution, both individuals and the separate states, including Vermont, Massachusetts, New Jersey and Kentucky, exercised the right of making metallic money, but their issues were practically limited to copper cents or half cents. Paper money had been issued by several colonies before the Declaration of Independence, but always based on Spanish milled dollars.

The first Continental Congress met in Philadelphia Sept. 5, 1774, and the second May 10, 1775, but the idea of a national coinage was not suggested in either. The first financial committee was appointed June 3, 1775, to "prepare an estimate of the money required to pay the expenses of Congress." In four days they reported in favor of bills of credit. Several committees

were subsequently appointed with constantly enlarging powers, till in 1776 a Treasury Board was organized with a committee on claims. The latter was soon dispensed with, and the first was found a cumbrous machine, severely criticized by Robert Morris, whose proposition to appoint a regular treasurer was opposed by one Payne, a self constituted watch dog of the people's money, who objected to the increase of officers and the payment of salaries. It was 1779 before the Treasury Department of the United States was fully organized. The principal money the government had was bills of credit, or some form of paper currency, the first supply being in the form of a loan for 6,000 pounds, and the second bills of credit not exceeding 2,000,000 Spanish milled dollars. Thus we see that the pound and the dollar as denominations of money had equal standing at that time. Comparatively little coin was in the country, and most of it of foreign mintage, but several of the colonies had already issued paper money. Many people were impressed at that time, just as they are now, with the facility of this form of making money, and when the question of the best way to meet the expenses of Congress was in debate, one member said: "Do you think, gentlemen, that I will consent to load my constituents with taxes when we can send to our printer and get a wagon load of money, one quire of which will pay for the whole?" In a little more than a year 15,000,000 dollars were authorized, and depreciation began. It does not appear that the word pounds was used after the first loan. One of the issues of paper money provided for small bills of 2-3, 1-3, 1-6, 1-9 of a dollar, so that the first authorized subdivision of the dollar was partially on the binary system. The need of money by Congress was great, and one of the schemes proposed was a lottery. The British government had frequently raised money by lotteries, and in fact some of the money for the subjugation of the colonies was obtained in that way. Congress had as yet no power to raise money by taxation of any kind, and the colonies who had rebelled against Great Britain on the question of taxes were slow to surrender rights they were struggling so hard to gain. The property of loyalists was confiscated and sold, and when, at the discussion as to terms of peace, the

British commissioners proposed restitution, it was refused, first on the ground that it was the act of the several states, and secondly that it was no more than compensation for the private property destroyed by the British, contrary to the laws of war. We have, in fact, in the discussions of those times, precedents for all the questions arising out of the Spanish war. The next expedient of Congress for getting money was the French loan, and here the French denominations had to be considered, and it was to be at the rate of five livres for a dollar. At the end of 1779 200,000,000 dollars of paper money had been issued, and it had become nearly worthless.

In 1781 for the first time, by the articles of Confederation, the states surrendered to Congress the regulation of coinage, weights and measures, making the United States as a whole responsible for bills of credit or loans, in place of individual states. Robert Morris was appointed Superintendent of Finance, and the ineffective and changeable Treasury Board was replaced by a thoroughly competent executive officer. That the denominations of money at this time in use were very numerous we find from a letter of John Adams, who says that "Guineas, half Joes, and Spanish milled dollars are in high estimation, being coin of three different nations." On the 15th of January, 1782, Morris prepared a report on the foreign coins in circulation in the United States, with a plan for American coinage. He had already employed a Mr. Dudley, had had the silver coins in circulation assayed, and had devised plans for machinery to make coin. On April 2, 1783, Mr. Dudley delivered to Mr. Morris the first American silver coin, that is, American in the sense of United States. The preparation of pattern coins was urged forward, and on April 22, several pattern American coins were furnished to lay before Congress. Notwithstanding this beginning, it was ten years before actual coinage was commenced.

The treaty of Paris was signed in 1783 and the United States became an independent nation. In November, 1784, Morris resigned, before any action had been taken by Congress on his report on coinage. This report proposed a very small unit of about 0.07 of a cent, but it also proposed a decimal subdivision.

When Morris resigned Congress appointed a committee to consider the matter of coins and currency and their report was drawn up by Thomas Jefferson. He considered Morris's unit as entirely too small, and proposed the Spanish dollar as "being of convenient size, capable of easy division, and familiar to the people." He agreed with Morris on the matter of decimal subdivision, and said, "The most easy ratio of multiplication and division is that of ten. Every one knows the facility of decimal arithmetic." Acting on this report Congress on July 6, 1785, passed an act defining the money of the United States to be one dollar as a unit, the smallest coin to be copper, 200 to the dollar, the next copper, 100 to the dollar and weighing 2¼ pounds avoirdupois. The dollar shall contain of silver, 11 parts fine, 375 64-100 grains, and there shall be three silver coins besides, a half dollar, a double dime, and a dime; also there shall be two gold coins, one with 246 268-1000 grains of fine gold, equal to ten dollars, to be stamped with the impression of the American eagle and to be called an eagle, and one containing 123 134-1000 grains of fine gold, equal to five dollars, to be stamped in like manner, and to be called a half eagle. Thus the money of the United States was born. In addition to the actual coins the 1-1000 part of a dollar was added as a money of account, to be called a mill. The United States money was thus at first on a purely silver basis, but had a double standard, the value of both gold and silver coins being fixed by law. On the basis of this act a second attempt was made to establish a mint, several dies were procured, a few copper coins, including the Franklin cent, were struck by private contractors, but no regular issue was ever made. It was not until April 15, 1790, that Congress instructed Hamilton, then Secretary of the Treasury, to prepare a plan for the establishment of a United States mint. He brought in his report at the next session, and on March 3, 1791, President Washington affixed his signature to the bill which gave to the United States an actual currency of its own, agreeing substantially with the act passed five years before, and nine years after the treaty of independence. The decimal subdivision of our money we owe to **Robert Morris**, supported by Thomas Jefferson; the dollar as a

unit of value was simply selected from the great variety of coins current in the United States at the time of the Revolution, as that which was most generally understood and most convenient.

The first silver coins supplied to the Treasury from the Mint were 1758 dollars made from "coins of France" and furnished Oct. 15, 1794. The first gold coins were made from ingots July 31, 1795, 744 half eagles.

America was not the first country to have a decimal currency. China has always had it in small coins, 100 cash to one Mace, and Russia 100 copecks to one rouble, which is sometimes called dolyah, though only 50 cents value.

The dollar, or a coin varying less than 10 per cent in value and of the same name, is now in use in the United States, British America, Mexico, Honduras, Colombia, Equador, Haiti, Liberia, Uruguay, Portugal, Japan (gold yen), and to a considerable extent in China.

France, Spain, Italy, Austria-Hungary, Belgium, Greece, Finland, Switzerland, and Venezuela belong to the Latin Union, in which the franc is the nominal unit, but as the five franc piece approximates in value closely to the dollar, all these countries may be considered as having a uniform coin. This leaves Germany with the mark, Russia with the rouble, and England with the pound as the only aberrant coinages in use by civilized countries, and if an international coin shall ever be adopted, it seems reasonable that it will be the dollar.

Certain it is that no term was ever so widely understood over the whole world as the name of the universal Yankee dollar.

Among the books of information on this subject, Bolles' *Financial History of the United States* occupies the first place, Evans' *History of the United States Mint and Coinage* comes next, and other works to be consulted are *The History of Ancient and Modern Coinage*, by Laban Heah Heath & Co., Boston, and *The History of Money in America* by A Del Mar.

NOTES.

Literature on Weights and Measures.—The editor of the Metrology column, while thanking many persons interested in metric reform who have assisted him, would respectfully ask anyone who sees, in the monthly magazines or the daily or weekly press, either long articles or brief notes on the subject of measures or weights, especially metric, to call his attention to them, stating the name of the periodical, with date and page where found, if not convenient to forward the article itself.

La convention du Métre et le Bureau internationale des Poids et Mesures, by Ch. Ed. Guillaume, is a quarto work of 238 pages which contains a very complete account of what has been done by the International Bureau at Breteuil, France. This Bureau was the outcome of the International Metric Convention, which met at Paris in 1870. The work is opportune in view of the new Bureau of Standards at Washington, and of the renewed interest in the metric system in both England and America, and forms a fitting sequel to the classic work of Bigourdan—*Le Systeme Metrique des Poids et Mesures,* issued last year. The work in the well equipped laboratories is described, and illustrated by 88 diagrams. The work on the *Metre des Archives,* to furnish an international standard of length, was very exhaustive. The many discrepancies in determining the weight of a cubic decimeter of water finally led to the adoption of a certain iridio-platinum weight as the kilogram. · Much work has been done on thermometry, and on the expansion and contraction of various kinds of glass. With a toluene thermometer a temperature of —74° C. is measured with an accuracy of 0°.05, and there are standard barometers measuring an atmospheric pressure to 0.01 mm. of mercury. There are three kinds of comparators, one for measuring the meter, another for the calibration of tubes, etc., and a third for ascertaining the expansion and contraction of metals. Much original work has been done, as, for example, on nickel steel, which, with 36 per cent nickel, is found to have a very low coefficient of expansion.

In *Cassier's Magazine* for August, E. Sherman Gould criticises the metric system as not being so easy for the field worker or artisan as the units of the English system, though shorter and simpler for the office computer, and he argues that the practical measurer rather than the figurer should be specially favored, basing on this argument an objection to the International System. The inch, foot, yard, fathom and mile, he asserts, are more convenient as measures than the metric units. If this were generally true, it would be a serious objection to the latter system, but it is a sufficient answer that many civil engineers and skilled workmen in various lines after having used both systems prefer the metric. Be-

sides, we have yet to learn that manipulators of measuring instruments in metric countries are less clever than those in non-metric. While allowing that each of the English units can be and is decimalized when desired, the author falls into the common error of assuming that metric units cannot be halved. In view of the marvelous work done on the meridian by Delambre and Mechain, not to mention others, the following statement seems absurd: "The metric system, on the other hand, is the scientifically beautiful conception of a coterie of savants who probably never in their lives had occasion to make a single practical measurement." Mr. Gould regards it a great misfortune that the meter had not been exactly 40 inches instead of 39.37, as in that case the two systems would have been easily interchangeable.

R. P. W.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of great value.

BIOLOGY.

The Marine Biological Laboratory, Woods Holl, Mass., well known to many teachers, has become part of the Carnegie Institution, which will take care of the financial interests. New buildings for permanent laboratories and library, new equipment of boats, etc., are some of the improvements proposed. Its administration and policy are to remain, as heretofore, in the hands of the scientists of the country. Among many teachers the question arises, what will become of the courses in instruction and of those students who have been able to do only small things so far? Professor McKeen Cattell, of Columbia University, in an article in *Science* (September 19), gives the key-note idea on which the Carnegie Institution was founded (in the words of the founder): "To discover the exceptional man in every department of study whenever and wherever found, and enable him to make the work for which he seems specially designed his life work." Then he goes on to say: "We can only find the exceptional man by selecting him from a considerable number who undertake research work. Those who prove themselves incompetent for important original investigations have not wasted their time but are better prepared for teaching or other kinds of work." It

NOTES.

Literature on Weights and Measures.—The editor of the Metrology column, while thanking many persons interested in metric reform who have assisted him, would respectfully ask anyone who sees, in the monthly magazines or the daily or weekly press, either long articles or brief notes on the subject of measures or weights, especially metric, to call his attention to them, stating the name of the periodical, with date and page where found, if not convenient to forward the article itself.

La convention du Métre et le Bureau internationale des Poids et Mesures, by Ch. Ed. Guillaume, is a quarto work of 238 pages which contains a very complete account of what has been done by the International Bureau at Breteuil, France. This Bureau was the outcome of the International Metric Convention, which met at Paris in 1870. The work is opportune in view of the new Bureau of Standards at Washington, and of the renewed interest in the metric system in both England and America, and forms a fitting sequel to the classic work of Bigourdan—*Le Systeme Metrique des Poids et Mesures,* issued last year. The work in the well equipped laboratories is described, and illustrated by 88 diagrams. The work on the *Metre des Archives,* to furnish an international standard of length, was very exhaustive. The many discrepancies in determining the weight of a cubic decimeter of water finally led to the adoption of a certain iridio-platinum weight as the kilogram. · Much work has been done on thermometry, and on the expansion and contraction of various kinds of glass. With a toluene thermometer a temperature of —74° C. is measured with an accuracy of 0°.05, and there are standard barometers measuring an atmospheric pressure to 0.01 mm. of mercury. There are three kinds of comparators, one for measuring the meter, another for the calibration of tubes, etc., and a third for ascertaining the expansion and contraction of metals. Much original work has been done, as, for example, on nickel steel, which, with 36 per cent nickel, is found to have a very low coefficient of expansion.

In *Cassier's Magazine* for August, E. Sherman Gould criticises the metric system as not being so easy for the field worker or artisan as the units of the English system, though shorter and simpler for the office computer, and he argues that the practical measurer rather than the figurer should be specially favored, basing on this argument an objection to the International System. The inch, foot, yard, fathom and mile, he asserts, are more convenient as measures than the metric units. If this were generally true, it would be a serious objection to the latter system, but it is a sufficient answer that many civil engineers and skilled workmen in various lines after having used both systems prefer the metric. Be-

sides. we have yet to learn that manipulators of measuring instruments in metric countries are less clever than those in non-metric. While allowing that each of the English units can be and is decimalized when desired. the author falls into the common error of assuming that metric units cannot be halved. In view of the marvelous work done on the meridian by Delambre and Mechain, not to mention others, the following statement seems absurd: "The metric system, on the other hand, is the scientifically beautiful conception of a coterie of savants who probably never in their lives had occasion to make a single practical measurement." Mr. Gould regards it a great misfortune that the meter had not been exactly 40 inches instead of 39.37, as in that case the two systems would have been easily interchangeable.

R. P. W.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of great value.

BIOLOGY.

The Marine Biological Laboratory, Woods Holl, Mass., well known to many teachers, has become part of the Carnegie Institution, which will take care of the financial interests. New buildings for permanent laboratories and library, new equipment of boats, etc., are some of the improvements proposed. Its administration and policy are to remain, as heretofore, in the hands of the scientists of the country. Among many teachers the question arises, what will become of the courses in instruction and of those students who have been able to do only small things so far? Professor McKeen Cattell, of Columbia University, in an article in *Science* (September 19), gives the key-note idea on which the Carnegie Institution was founded (in the words of the founder): "To discover the exceptional man in every department of study whenever and wherever found and enable him to make the work for which he seems specially [illegible] life work." Then he goes on to say: "We can only find the exceptional man by selecting him from a considerable number who [illegible] research work. Those who prove themselves incompetent for important original investigations have not wasted their time but [illegible] prepared for teaching or other kinds of work." It

seems probable that the more elementary character of the courses will change to one leading only to research. Yet this has really been the dominant idea all along.

A useful key for the identification of workers of the family Formicidae is given in the September number of the *American Naturalist,* by Dr. W. M. Wheeler, of the University of Texas. Those interested in ant studies will find other papers of Dr. Wheeler's along this line in preceding numbers of the same journal.

The migration of birds, according to C. C. Trowbridge (September number of the *Am. Nat.*), is due to direction and influence of favorable winds, and not temperature, as has been held by other observers.

Teachers who may wish to keep some marine animals inland will be interested in the experiments of Dr. R. True, on *synthetic sea water.* In *Science,* September 12, he tells about keeping algae through the spore stage, jellyfishes, molluscs and fishes, for longer periods of time. Dr. True's experiments at Woods Holl, this last summer, fully justify all that he has said. In some cases the organisms looked better than they did in the normal sea water. The formula will, no doubt, be published later and can then be given to the readers of SCHOOL SCIENCE.

Osmosis; Simple Methods.—Probably the most satisfactory of all is the diffusion cell mentioned in *Ganong's Physiology* (Holt & Co.). The use of an egg for this purpose is so well known as not to need description. It is a little difficult for young students to manage. A simpler form is the half shell of a used egg, from the end of which a few fragments of shell are removed, sugar placed inside, and the whole floated on a dish of "soil water" over night. In this case pupils can see what is going on.

Peabody's Laboratory Physiology recommends sheep's intestine, cleaned, inflated, tied in sausage-shaped segments, and dried. Miss Ellis, Grand Rapids High School, suggests sausage membranes. This might be used in home experiments. The thin membranes between the layers of an onion have been used with varying success. Simpler than this is the method given in Atkinson's "First Studies of Plants," to tie a leaf over the end of a tube, etc.

But simplest of all is the use of a carrot, itself a root, or a potato, given in Macdougal's "The Nature and Work of Plants." Sugar is placed in a hollow made in the carrot or potato and the end cut off so that the bottom may stand in a dish of water one inch deep. A narrow opening, such as might be made with a cork borer, and fitted with a glass tube would show the rise of fluid more easily.

L. M.

GEOLOGY.

A somewhat novel entertainment was given recently by the class in physical geography of the Tama City High School, Iowa, under the title of "Ice and Ice Work." The program consisted of four numbers by members of the class: "The Ice Rivers of the Alps," "The Glaciers of America," "The Frozen Sahara of Greenland," and "The Age of the Great Ice," illustrated by 100 lantern slides loaned by the Department of Geology of Cornell College, Iowa. The program was under the charge of the instructor in science in the high school, Mr. Ralph Williamson.

W. H. NORTON.

Free for the Asking.—By a joint resolution of Congress, the bulletins of the United States Geological Survey, previously sold by the survey, will be distributed gratuitously. The bulletins have been classified in seven series: A, economic geology; B, descriptive geology; C, systematic geology and paleontology; D, petrography and mineralogy; E, chemistry and physics; F, geography; G, miscellaneous.

These bulletins are to some extent technical, but contain a large mass of valuable information for the teacher and student which can now be obtained for the asking. Requests should be forwarded to the Directors of the Geological Survey and should indicate clearly what is wanted, preferably by number. On application to the Director a pamphlet containing a list of all publications of the survey and directions for obtaining them will be furnished.

E. C. C.

CHEMISTRY.

Improved Method of Applying Test for Nitrates.—The usual method of applying the "copperas test" is to mix with sulfuric acid the solution to be tested for nitrates, then to incline the test tube and carefully pour ferrous sulfate solution down the inclined tube in such a way as to have it lie on the surface and expose the brown ring at the junction of the two liquids. The difficulty of successfully doing the last part makes this method awkward. Some years ago I hit upon the following plan, which works admirably: Mix with copperas solution the liquid to be tested, then introduce a thistle tube, running it to the bottom of the test tube, and, with the left hand holding it, together with the test tube, in a vertical position, pour three or four cubic centimeters of sulfuric acid through the thistle tube. In virtue of its superior specific gravity, the acid remains at the bottom, forcing up the other liquid. *If the thistle tube is not disturbed,* the brown ring will at once appear in case a nitrate is present, and much more distinctly than by the usual method.

R. P. W.

The Lime-water Test for Carbon Dioxide.—In testing a gas for carbon dioxide by means of lime-water, two methods are prescribed by manuals generally. One is to conduct the gas into lime-water by a delivery tube; the other is to hold a glass rod, after being dipped in lime-water, in the escaping gas. The former method is often inconvenient, and the latter (the more common one in elementary work) gives much less satisfactory results with beginning students than the reliability of the test warrants. It may, therefore, not be out of place to call attention to a simple method, intermediate to these two, which is quite satisfactory.

A cork of the right size for the test tubes used is fitted with a glass tube of at least 7 mm. internal diameter. By dipping the lower end of the tube into lime-water, a capillary drop can be picked up. The cork is then fitted into the test tube, from which the gas is escaping, just so tightly that the gas slowly bubbles through the drop of lime-water in the end of the tube. The cloudiness becomes very apparent at once, if carbon dioxide is present. It is needless to say that the tube may always be kept in readiness for this purpose.

H. C. Cooper.

To Determine Per Cent of Nitrogen in Air.—Close a large test tube with a tight-fitting, one-hole cork, containing a glass tube drawn out to a fine point and closed there, pointed end outside. Drop into the tube a small piece of phosphorus and replace cork quickly. Ignite the phosphorus by dipping the tube into hot water. Shake the burning phosphorus along the side of the test tube, and, when it has stopped burning, break off the pointed end of the delivery tube under water. The rising water will mark the volume of oxygen consumed. Wait at least five minutes, then indicate the height of the water by a rubber band.

Measure with water the total capacity of tube, allowing for cork. Measure volume of gas left and calculate per cent of nitrogen in air. Results should not vary more than one per cent each way.

To Show that Oxidation Means Increase of Weight.—Protect one scale pan by a piece of metal and place on this a piece of metal gauze, about 3 inches by 1 inch, bent twice at right angles, to form a kind of grate one inch high. Sprinkle on it reduced iron and balance the whole. Heat the iron from below by a taper or Bunsen flame, and watch the pointer of the scale move, decidedly showing increase of weight due to burning. Note change in appearance of product.

Jessie F. Caplin.

Reports of Meetings.

N. E. A. ROUND TABLE CONFERENCE IN PHYSICAL SCIENCE.

MINNEAPOLIS, MINN., JULY 9, 1902.

Mr. W. A. Fiske, Richmond (Ind.) High School, *Leader.*

(*Concluded from page 249.*)

MISS KATE WYMAN (Faribault, H. S.), Northfield, Minn.: If Mechanics and Heat occupy about half the time devoted to the subject and Electricity the other half, what is to become of the rest of the work? On account of the size of the subject, it would be impossible, perhaps, to omit one of these topics given under Physics.

MR. P. S. BERG, Science, Larimore, N. D.: I think the leader is correct in stating that half the time should be given to Mechanics and Heat and the other half to the study of Electricity, Sound and Light. We all know that Magnetism does not occupy a very large part of the text book commonly used in the public schools. We further know, upon careful inquiry, that physics is a unit and not an aggregation of many disassociated subjects. When the pupil gets the proper conception of motion, conservation of energy, correlation of energy, electricity and a few other things he has physics; in fact, conservation and correlation of energy are at the basis of the entire subject. Now when the pupil has thoroughly learned Mechanics, has not that pupil the basic knowledge for working out Sound and Light and in good part Electricity?

There are a few things not mentioned in the outline, for instance, the time that physics should be offered. I feel in my experience that it would probably be best if physics were not offered until the last year in the high school. I get from the drift of remarks that were given here this afternoon that a great many problems should be given. I hardly agree with that. No pupil can ever get into real physics unless he is more or less the master of arithmetic, algebra and geometry. So these subjects, I think, should precede physics; and if they do, physics probably ought to come the last year in the high school. How can the pupil ever master specific heat and latent heat and perform the quantitative experiments and solve the problems which underlie them unless he has a well grounded knowledge of algebra? On the other hand, how can the pupil illustrate the principles in connection with Light unless he has some

knowledge of plane geometry? So I hold that after geometry, algebra and a thorough knowledge of arithmetic, physics can be made much more interesting and profitable.

Another thing that has been touched upon this afternoon is the order in which the experimental work, laboratory work and theoretical work and problems should come. This is my order: The theory first—text book work first; after that the experiment to illustrate the theory, after the experiment the problems to illustrate the experiment and the theory, or to strengthen what has been learned before. I hope to hear from others, both upon the time that physics should be offered and what we shall give first. Shall we first give the theory of the subject and then follow that up with experiments and then by problems?

MR. BARKER: Mr. Chairman—I have been requested to speak on the first subject in chemistry—Theoretical Chemistry—when presented, how much, etc. If I were essentially a teacher of physics, I presume I could agree with the last speaker and feel that physics should be given in the senior year, but as my subject is essentially chemistry, I believe chemistry should be given the last year and the entire year. I am perfectly willing that those who wish to give qualitative work the latter part of the year should do so, but for myself, I believe I could give the pupil so much more in theoretical chemistry and the application of it that I have no time to give to the qualitative work.

The approach of the subject by dogma or by experiment, with me has no two answers. I should by all means give the experiment first. I believe we have all passed through the stage when we at one time wanted to be an Indian, at another, a circus rider and so on until we arrive at what we consider to be the highest ground; and so in teaching, especially chemistry, I believe we ought to go at it, to a great extent, in the way it has been—if you wish, in the theoretical way in which chemistry has been developed.

Then the question of the chemical laws. For my own part, I should present first oxygen and when that one subject as an element were thoroughly mastered I would stop and develop a certain number of laws from that; then take hydrogen and the union of oxygen and hydrogen and more laws sandwiched in between. The first half of the year I should not attempt to get any further than the four subjects of oxygen, hydrogen, chlorine and nitrogen, at the same time bringing out almost all the principles of theoretical chemistry. We can utilize in so many ways almost every dogma of our live chemistry. These will present themselves to any teacher and the more practical applications you can get in the better. This is a question that may seem to be a little bit on the danger ground. We are not sure of ourselves when we get in the converse principles of chemistry or any other subject; in fact, whatever the theory may be I always try to distinctly put it as a theory, but I find it very hard work to make the pupils keep theory and law separated. They are always

getting theories as laws—stating them as absolute facts when they are mere theories—and you can say nothing more for them, but at the same time, if the theory is advanced by a man of recognized ability, I believe in bringing it to the notice of a class. If there is anything new on the subject, let the pupil have it; give him the latest and the best, always regarding the point that it may be theory; that there is nothing absolutely certain about it; that the facts can bear out this theory, but that it still is theory, nothing more. Recent theories, I believe, can be presented to a class with a reasonable degree of safety, if there is a reasonable degree of care, but with any theory, let the pupil be in that frame of mind that he can at any time allow that theory be overthrown and a better one take its place, if it shall be advanced, something that satisfies more of the conditions, if there be such a theory; and let the pupil always be ready to tear down the old theory if it doesn't answer all the requirements, and substitute a new one.

MR. FISKE: One of the recent theories that I believe is referred to here is the ionization theory.

In correspondence with some of the teachers of the East, I learn that they do not think very much of that theory and it was stated that the pupils were not able to get much out of it, but in correspondence and conversation with some of the Western teachers, I find that they think a great deal of the ionization theory, especially some of the Chicago teachers, and feel that they see more in it.

MR. TOWER: I want to emphasize that I believe the ionization theory is one that can be presented with a great deal of profit by high-school teachers. I have found it so and thoroughly believe in presenting it. However, that, as well as other theories, I should present at least in the last half of the year, and, better still, the last third, rather than before. It is all right enough to present laws in the first half of the year; I would put those in just as has been stated, but when it comes to theory, I would emphasize that in the last third rather than before. Then you have the facts based upon quantitative experiments, which ought to be included in every high-school course. They can't be such quantitative experiments as we have in the third year of chemistry, but they are sufficiently clear so they can be understood, and it will give that basis for the consideration of theory, which will not otherwise be secured by the pupil; and I thoroughly believe in quantitative experiments as a basis for laws, which, of course, are the basis of theory which we ought to present later in the course.

MR. FISKE: While I believe that physics is distinctly a mathematical subject, yet I further believe that some history should be worked in as well. Physics deals with Boyle's Law and the laws of Newton, and to teach about these laws and not about the men who formulated them, it seems to me something is left out, and in my work I make it a point in taking up these subjects, to have the whole class, or a few members

of the class, or even one member of the class, prepare something definite and to the point, in the way of biography of these men, and if it is possible have their picture before the class, that they may look upon the picture of the person who formulated these laws; and not only these, but any other names that are brought up in the subject of physics. Almost any history of science will give us a great deal of information on these biographical subjects. And I believe it is well to present just as much as we have time to present. This work can be assigned at the time of class and the matter worked out at their leisure.

PRIN. CHAS. A. SMITH: I would like to ask how much time you devote to laboratory work in the week and how much to recitation work?

MR. FISKE: I have five periods a week in physics. I am allowed that much time—five periods a week of 45 minutes each. That is not enough, but three of those periods are spent in the class room and two consecutive periods in the laboratory.

Q: You do not consider that enough?

MR. FISKE: I do not believe five periods a week is enough for a class of juniors in physics.

Q: May I ask you, then, if three periods of recitation and two double periods a week in the laboratory would be sufficient?

MR. FISKE: That would be better, yet I would prefer a little more class room work. If I had seven periods I believe I should take four of them to class room work and three for laboratory work, taking perhaps one period of the four for a special discussion of the work done in the laboratory.

Q: What would you do with the other three days?

MR. FISKE: They might be spent upon recitation and lecture work

Q: Where do problems come in?

MR. FISKE: I do not think it advisable in secondary schools to take a whole period for lecture purposes, but a portion for lecture purposes and the remainder for recitation and problems.

Q: Will you have more problem work with Electricity or Mechanics?

MR. FISKE: I find in my experience that I obtain better results in giving the greater number of problems from Mechanics and Heat, though there is a great field for that kind of work in the subject of Electricity.

Q: Now, come down to one of your questions here in the third division—Physics and Chemistry—Supervision of laboratory work, relation of teacher to pupil during working period.

MR. FISKE: I think the teacher during the working period should be right there with the pupil, at least where he can know positively what the pupil is doing and where he can be at the pupils' command. I do not make it a business, when I am in the laboratory, of passing around from pupil to pupil all the time. It is not necessary to do so. You can tell what they are doing and not be right where they are. If I see somebody

in trouble, who is apparently not doing what he should do, then I am where he is; and if he gets along all right with his experiment and finishes it, he comes to me, and we look it over together, and if it is satisfactorily done it is accepted and he is given another problem; and if it is not, the mistake is pointed out to him and he cheerfully goes back and corrects it—offers to do that, in the majority of cases, without being asked to do so.

Q: Do you give out problems for them to take home and solve, in addition to the laboratory problems?

MR. FISKE: I very often do so.

Q: How many do you take charge of in the laboratory?

MR. FISKE: I think fifteen is a large enough class for anybody in the laboratory. I have had some difficulty in holding it down to that number, but I have been able to do it so far. I won't have more than fifteen in the laboratory unless I have to.

MR. GOODELL: Now, in connection with the laboratory note book. The most important point to me is the time and place of making the record and just how much of a record it should be—whether just the data taken in the laboratory, or the results which are worked out from this data, or still more discussion of the experiment, or whether or not they should have the laboratory note book just one book or whether it should be first an original book or report handed in, and finally a finished book, written in ink and carefully prepared. I know there is a great difference of opinion on that point, which is one well worthy of discussion.

MISS CAPLIN: In chemistry—I speak from my own experience—I was always losing my mimeograph notes and I have tried all kinds of experiments until this last term, when I have been trying an entirely different scheme—making my mimeograph sheets the same size as the note book size and putting down on them the object and processes, and then have them file those with their notes and write out simply the answers to the questions and the conclusions. It seems to me that so much writing is a drudgery and that the time could much better be spent in other ways; and I think I have economized quite a little time in the laboratory by using loose sheets.

MR. TOWER: In physics, during the last two years, I have had the pupils write in ink permanent notes at the time the experiment is performed, and find that while there is perhaps the disadvantage of a thorough review outside of the experiment, in writing it up in permanent form at home, yet there is not only a great saving of time, but also a training in accuracy in putting down in proper form at the time the observations are made the exact results of experiments. So many people have to make two or three trials before getting a thing right, but if we can get our pupils to do it right first, it will be very helpful to them, and I find that making notes in permanent form in the laboratory has brought about this result to a certain extent.

MR. F. F. FARIAR, White Bear, Minn.: If the theory precedes the practice, then, in writing notes under this plan, do you have the theory thoroughly explained before letting the pupil try the experiment, or do you believe in the inductive method to a certain extent?

MR. TOWER: In answering that question, would say that I use no one method for all experiments. It depends also on the experiments. Some require explanation at the beginning and some of them they understand well enough themselves. They need a little help, of course, while doing it, in a certain way, at the time the experiments are done.

MR. FARIAR: Why I asked that question is because I have had difficulty, unless the subject was thoroughly explained, in most cases. Of course, some cases are very simple. It seems to me that if permanent notes are made at the time, they should have the subject quite thoroughly mastered before taking them.

MR. FISKE: The place, it seems to me, to write notes, is in the laboratory, just when the whole matter is red hot. Have the pupil put it down just at that time. I have had a little experience in allowing them to take notes out of the laboratory. They get behind on their notes three or four experiments; and then, more than that, after those notes have (as I have sometimes called it) become cold, they cannot do justice to the experiment. The time to write notes, it seems to me, is at the time the experiment is performed. There is some objection to that, which need not prevent us from having it that way, however, and that is that it takes a little more time. It is hardly just to make a few notes and then write up the experiment afterwards. I would prefer not so many experiments worked and have the pupils finish them right there before they leave them, because I believe better results can be obtained.

I would like to emphasize Miss Caplin's expression as to the saving of time. I use an ordinary note book and divide two pages in the middle, and in the first column at the top write, for instance, "Operation," in the second "Apparatus," in the third, on the next page, "Observation," and in the last, "Conclusion," which is the solution of the problem. That aids me greatly in looking over the notes. It is all finished on these two pages, which may be viewed at one time. What is done is said in one place, and it may be greatly abbreviated, because it is put in a certain place; and what is observed is in another place, and that can be greatly abbreviated; then the solution of the problem has a different place. This plan I have found of very great advantage to me, because so much abbreviation can be carried on.

MR. WM. E. ANDREWS, Taylorville, Ill.: I believe I have detected something of the craft of the college professor here this afternoon, because it seems to me there is a disposition to keep the note book in good form. That is proved in the discussion here, when one says the pupil's work should be well wrought out before he writes it down, if the note book

is to be made permanent at the time. Now, in my opinion, we should pay no attention to the statement in the university catalogues that the pupil's note book will be required. We should not, at least, pay so much attention to that as to lead us to try to get up a fine looking, errorless note book that will be damaging, highly damaging, to the work we need to do; and in my opinion, it would be better to have the pupils write out in the laboratory the work which they have done, to the best of their ability. Then have these notes come in and be carefully examined and errors indicated and record made, of course, if you care to keep a record, and let those leaves, as they have passed through the teacher's hands, with the errors indicated, be the permanent note book of the pupil. The place where the note book is to be prepared should be in the laboratory. There is only one reason under heaven to make a note book, and that is to keep the pupils' minds in the state of thinking and the help the pupil gets from the note-taking he needs to have when he is there with the apparatus, and get answers that the note-taking will cause to arise in his mind. So I think this plan is a good one. Do not try to get a fine looking note book, so that you may be rated high by the college professors, for if you undertake to get a note book that is a creditable looking one you are going to defeat the purpose of the work. Now, I would like to say just a word with reference to that point under 2,—"time given to note book inspection." There is just this thought: You know that the tremendous bore of the science teacher's life is reading the same old stuff year after year, and sheet after sheet, until it is perfectly nauseating. In speaking of the bad place, we think of a place that is very hot, but to my mind the very worst place to put a teacher for eternal punishment would be in a room where there was nothing to read at all but papers, note book papers, and from that kind of punishment, good Lord, deliver us! Dr. Hall has said that if we would stay up more in the day time to prevent errors, we need not stay up so much at night to correct them. Now, the thing that bothers me most in science work is this awful question of being deluged with papers—what to do with them. How can we get the very best effort of the pupil on the papers so as not to have to spend all the very best time of our lives on this work?

Q. Now, if a pupil perform an experiment very smoothly and carefully, and the result is not satisfactory to them ,would that pupil not be required, in such a case, to take the experiment over?

Mr. Andrews: That would appear in the credit which he receives. There is a certain minimum credit which the pupil would have to obtain. It would be wholly termed discredit and it would stand just as a zero would in mathematical work. Now, the benefit is just here—that through being discredited, the fact that they know when they write the first draft that it is upon that the credit is to come, they are very much

more careful in that draft, and they do not pour in upon you every day unmeasured quantities of the same old carelessness and slovenliness as they would if they knew that slovenliness could be done over again and corrected for them.

MR. FISKE: I should like to emphasize that point brought out about saving the teacher's energy and strength and not having so many note books to look over. I do not believe we can afford to do it. I believe we owe it to ourselves and to our pupils to be more than mere machines in this matter. I think if we spend our time in the evenings on anything, and we certainly should, it should not be note books or papers in relation to our school work, but it should be something we can take to our class next day that will give them food for thought and put them on a higher plane than they were the day before. There are teachers who are killing themselves—dragging out their lives looking over notes and papers—and sometimes I feel sorry for them, carrying home whole loads and stacks of papers to be examined that individual night—it must be done before the next morning—and the teacher ought to be free. He can't afford to do these things. Something must be done to economize the time and get the matter in a nutshell, so we will have more time for freedom and thought along different lines than those we are grinding over in the day time. I never take a note book home. I look them over, as I said a moment ago, just as soon as they are done, and then I am through with them.

MR. TOWER: I would like to make a suggestion. As we said in the first place, we would not have enough time and I feel that there are points here that I should like to hear discussed and wonder if it would not be best to have a meeting in the morning. The general program does not interest all, and perhaps we could find out the number that could be here and would like to have such a discussion.

MR. FISKE: We might take the most important points and finish the matter up now. If we could have a meeting, and get it circulated, it might be all right, but it would cause those present some inconvenience to get here again. We are all, no doubt, very much interested in this matter and willing to stay twenty minutes to half an hour longer, but as it is getting late it might be well to adjourn.

The conference adjourned after a two hours' session at 7:00 p. m.

School Science

VOL. II] DECEMBER, 1902. [No. 6

LIQUID HYDROGEN AND HELIUM.*

BY JAMES DEWAR.

Hydrogen is an element of especial interest, because the study of its properties and chemical relations led great chemists like Faraday, Dumas, Daniell, Graham and Andrews to entertain the view that if it could ever be brought into the state of liquid or solid it would reveal metallic characters. Looking to the special chemical relations of the combined hydrogen in water, alkaline oxides, acids and salts, together with the behavior of these substances on electrolysis, we are forced to conclude that hydrogen behaves as the analogue of a metal. After the beautiful discovery of Graham that palladium can absorb some hundreds of times its own volume of hydrogen, and still retain its luster and general metallic character, the impression that hydrogen was probably a member of the metallic group became very general. The only chemist who adopted another view was my distinguished predecessor, Professor Odling. In his "Manual of Chemistry," published in 1861, he pointed out that hydrogen has chlorous as well as basic relations, and that they are as decided, important, and frequent as its other relations. From such considerations he arrived at the conclusion that hydrogen is essentially a neutral or intermediate body, and therefore we should not expect to find liquid or solid hydrogen possess the appearance of a metal. This extraordinary prevision, so characteristic of Odling, was proved to be correct some thirty-seven years after it was made. Another curious

* Part of the address of the president of the British Association for the Advancemen of Science delivered at Belfast, Ireland, in September, 1902.

anticipation was made by Dumas in a letter addressed to Pictet, in which he says that the metal most analogous to hydrogen is magnesium, and that probably both elements have the same atomic volume, so that the density of hydrogen, for this reason, would be about the value elicited by subsequent experiments. Later on, in 1872, when Newlands began to arrange the elements in periodic groups, he regarded hydrogen as the lowest member of the chlorine family; but Mendeleef in his later classification, placed hydrogen in the group of the alkaline metals; on the other hand, Dr. Johnstone Stoney classes hydrogen with the alkaline earth metals and magnesium. From this speculative divergency it is clear no definite conclusion could be reached regarding the physical properties of liquid or solid hydrogen, and the only way to arrive at the truth was to prosecute low-temperature research until success attended the efforts to produce its liquefaction. This result I definitely obtained in 1898. The case of liquid hydrogen is, in fact, an excellent ilustration of the truth already referred to, that no theoretical forecast, however apparently justified by analogy, can be finally accepted as true until confirmed by actual experiment. Liquid hydrogen is a colorless transparent body of extraordinary intrinsic interest. It has a clearly defined surface, is easily seen, drops well, in spite of the fact that its surface tension is only the thirty-fifth part of that of water, or about one-fifth that of liquid air, and can be poured easily from vessel to vessel. The liquid does not conduct electricity, and, if anything, is slightly diamagnetic. Compared with an equal volume of liquid air, it requires only one-fifth the quantity of heat for vaporization; on the other hand, its specific heat is ten times that of liquid air or five times that of water. The coefficient of expansion of the fluid is remarkable, being about ten times that of gas; it is by far the lightest liquid known to exist, its density being only one-fourteenth that of water; the lightest liquid previously known was liquid marsh gas, which is six times heavier. The only solid which has so small density as to float upon its surface is a piece of pith wood. It is by far the coldest liquid known. At ordinary atmospheric pressure it boils at *minus* 252.5 degrees or 20.5 degrees absolute. The critical point of the liquid is about 29 degrees absolute, and the critical pressure not more than fifteen atmospheres. The vapor of

the hydrogen arising from the liquid has nearly the density of air—that is, it is fourteen times that of the gas at the ordinary temperature. Reduction of the pressure by an air-pump brings down the temperature to *minus* 258 degrees, when the liquid becomes a solid resembling frozen foam, and this by further exhaustion is cooled to *minus* 260 degrees, or 13 degrees absolute, which is the lowest steady temperature that has been reached. The solid may also be got in the form of a clear transparent ice, melting at about 15 degrees absolute, under a pressure of 55 mm., possessing the unique density of one-eleventh that of water. Such cold involves the solidification of every gaseous substance but one that is at present definitely known to the chemist, and so liquid hydrogen introduces the investigator to a world of solid bodies. The contrast between this refrigerating substance and liquid air is most remarkable. On the removal of the loose plug of cotton-wool used to cover the mouth of the vacuum vessel in which it is stored, the action is followed by a miniature snowstorm of solid air, formed by the freezing of the atmosphere at the point where it comes into contact with the cold vapor rising from the liquid. This solid air falls into the vessel and accumulates as a white snow at the bottom of the liquid hydrogen. When the outside of an ordinary test-tube is cooled by immersion in the liquid, it is soon observed to fill up with solid air, and if the tube be now lifted out a double effect is visible, for liquid air is produced both in the inside and on the outside of the tube—in the one case by the melting of the solid, and in the other by condensation from the atmosphere. A tuft of cotton-wool soaked in the liquid and then held near the pole of a strong magnet is attracted, and it might be inferred therefrom that liquid hydrogen is a magnetic body. This, however, is not the case; the attraction is due neither to the cotton-wool nor to the hydrogen—which indeed evaporates almost as soon as the tuft is taken out of the liquid—but to the oxygen of the air, which is well known to be a magnetic body, frozen in the wool by the extreme cold.

The strong condensing powers of liquid hydrogen afford a simple means of producing vacua of very high tenuity. When one end of a sealed tube containing ordinary air is placed for a short time in the liquid, the contained air accumulates as a

solid at the bottom, while the higher part is almost entirely deprived of particles of gas. So perfect is the vacuum thus formed that the electric discharge can be made to pass only with the greatest difficulty. Another important application of liquid air, liquid hydrogen, etc., is as analytic agents. Thus, if a gaseous mixture be cooled by means of liquid oxygen, only those constituents will be left in the gaseous state which are less condensable than oxygen. Similarly, if this gaseous residue be in its turn cooled in liquid hydrogen a still further separation will be effected, everything that is less volatile than hydrogen being condensed to a liquid or solid. By proceeding in this fashion it has been found possible to isolate helium from a mixture in which it is present to the extent of only one part in one thousand. By the evaporation of solid hydrogen under the air-pump we can reach within 13 or 14 degrees of the zero, but there or thereabouts our progress is barred. This gap of 13 degrees might seem at first sight insignificant in comparison with the hundreds that have already been conquered. But to win one degree low down the scale is quite a different matter from doing so at higher temperatures; in fact, to annihilate these few remaining degrees would be a far greater achievement than any so far accomplished in low-temperature research. For the difficulty is twofold, having to do partly with process and partly with material. The application of the methods used in the liquefaction of gases becomes continually harder and more troublesome as the working temperature is reduced; thus, to pass from liquid air to liquid hydrogen—a difference of 60 degrees—is, from a thermodynamic point of view, as difficult as to bridge the gap of 150 degrees that separates liquid chlorine and liquid air. By the use of a new liquid gas exceeding hydrogen in volatility to the same extent as hydrogen does nitrogen, the investigator might get to within five degrees of the zero; but even a second hypothetical substance, again exceeding the first one in volatility to an equal extent, would not suffice to bring him quite to the point of his ambition. That the zero will ever be reached by man is extremely improbable. A thermometer introduced into regions outside the uttermost confines of the earth's atmosphere might approach the absolute zero, provided that its parts were highly transparent to all kinds of radiation, otherwise it would be affected by the

radiation of the sun, and would therefore become heated. But supposing all difficulties to be overcome, and the experimenter to be able to reach within a few degrees of the zero, it is by no means certain that he would find the near approach of the death of matter sometimes pictured. Any forecast of the phenomena that would be seen must be based on the assumption that there is continuity between the processes studied at attainable temperatures and those which take place at still lower ones. Is such an assumption justified? It is true that many changes in the properties of substances have been found to vary steadily with the degree of cold to which they are exposed. But it would be rash to take for granted that the changes which have been traced in explored regions continue to the same extent and in the same direction in those which are as yet unexplored. Of such a breakdown low-temperature research has already yielded a direct proof at least in one case. A series of experiments with pure metals showed that their electric resistance gradually decreases as they are cooled to lower and lower temperatures, in such ratio that it appeared probable that at the zero of absolute temperature they would have no resistance at all and would become perfect conductors of electricity. This was the inference that seemed justifiable by observations taken at depths of cold which can be obtained by means of liquid air and less powerful refrigerants. But with the advent of the more powerful refrigerant liquid hydrogen it became necessary to revise that conclusion. A discrepancy was first observed when a platinum resistance thermometer was used to ascertain the temperature of that liquid boiling under atmospheric and reduced pressure. All known liquids, when forced to evaporate quickly by being placed in the exhausted receiver of an air-pump, undergo a reduction in temperature, but when hydrogen was treated in this way it appeared to be an exception. The resistance thermometer showed no such reduction as was expected, and it became a question whether it was the hydrogen or the thermometer that was behaving abnormally. Ultimately, by the adoption of other thermometrical appliances, the temperature of the hydrogen was proved to be lowered by exhaustion as theory indicated. Hence it was the platinum thermometer which had broken down; in other words, the electrical

resistance of the metal employed in its construction was not, at temperatures about *minus* 250° C., decreased by cold in the same proportion as at temperatures about *minus* 200°. This being the case, there is no longer any reason to suppose that at the absolute zero platinum would become a perfect conductor of electricity; and in view of the silimarity between the behavior of platinum and that of other pure metals in respect of temperature and conductivity, the presumption is that the same is true of them also. At any rate, the knowledge that in the case of at least one property of matter we have succeeded in attaining a depth of cold sufficient to bring about unexpected change in the law expressing the variation of that property with temperature is sufficient to show the necessity for extreme caution in extending our inferences regarding the properties of matter near the zero of temperature. Lord Kelvin evidently anticipates the possibility of more remarkable electrical properties being met with in the metals near the zero. A theoretical investigation on the relation of "electrions" and atoms has led him to suggest a hypothetical metal having the following remarkable properties; below one degree absolute it is a perfect insulator of electricity, at two degrees it shows noticeable conductivity, and at six degrees it possesses high conductivity. It may be safely predicted that liquid hydrogen will be the means by which many obscure problems of physics and chemistry will ultimately be solved, so that the liquefaction of the last of the old permanent gases is as pregnant now with future consequences of great scientific moment as was the liquefaction of chlorine in the early years of the last century.

The next step towards the absolute zero is to find another gas more volatile than hydrogen, and that we possess in the gas occurring in clevite, identified by Ramsay as helium, a gas which is widely distributed, like hydrogen, in the sun, stars and nebulæ. A specimen of this gas was subjected by Olszewski to liquid air temperatures, combined with compression and subsequent expansion, following the Cailletet method, and resulted in his being unable to discover any appearance of liquefaction, even in the form of mist. His experiments led him to infer that the boiling-point of the substance is probably below nine degrees absolute. After Lord Rayleigh had found a new source of helium in the

gases which are derived from the Bath springs, and liquid hydrogen became available as a cooling agent, a specimen of helium cooled in liquid hydrogen showed the formation of fluid, but this turned out to be owing to the presence of an unknown admixture of other gases. As a matter of fact, a year before the date of this experiment, I had recorded indications of the presence of unknown gases in the spectrum of helium derived from this source. When subsequently such condensable constituents were removed, the purified helium showed no signs of liquefaction, even when compressed to eighty atmospheres, while the tube containing it was surrounded with solid hydrogen. Further, on suddenly expanding, no instantaneous mist appeared. Thus helium was definitely proved to be a much more volatile substance than hydrogen in either the liquid or solid condition. The inference to be drawn from the adiabatic expansion effected under the circumstances is that helium must have touched a temperature of from nine to ten degrees for a short time without showing any signs of liquefaction, and consequently that the critical point must be still lower. This would force us to anticipate that the boiling-point of the liquid will be about five degrees absolute, or liquid helium will be four times more volatile than liquid hydrogen, just as liquid hydrogen is four times more volatile than liquid air. Although the liquefaction of the gas is a problem for the future, this does not prevent us from safely anticipating some of the properties of the fluid body. It would be twice as dense as liquid hydrogen, with a critical pressure of only four or five atmospheres. The liquid would possess a very feeble surface-tension, and its compressibility and expansibility would be about four times that of liquid hydrogen, while the heat required to vaporize the molecule would be about one-fourth that of liquid hydrogen. Heating the liquid one degree above its boiling-point would raise the pressure by one and three-fourth atmospheres, which is more than four times the increment for liquid hydrogen. The liquid would be only seventeen times denser than its vapor, whereas liquid hydrogen is sixty-five times denser than the gas it gives off. Only some three or four degrees would separate the critical temperature from the boiling-point and the melting-point, whereas in liquid hydrogen the separation is respectively ten and

fifteen degrees. As the liquid refractivities for oxygen, nitrogen, and hydrogen are closely proportional to the gaseous values, and as Lord Rayleigh has shown that helium has only one-fourth the refractivity of hydrogen, although it is twice as dense, we must infer that the refractivity of liquid helium would also be about one-fourth that of liquid hydrogen. Now hydrogen has the smallest refractivity of any known liquid, and yet liquid helium will have only about one-fourth of this value—comparable, in fact, with liquid hydrogen just below its critical point. This means that the liquid will be quite exceptional in its optical properties and very difficult to see. This may be the explanation of why no mist has been seen on its adiabatic expansion from the lowest temperatures. Taking all these remarkable properties of the liquid into consideration, one is afraid to predict that we are at present able to cope with the difficulties involved in its production and collection. Provided the critical point is, however, not below eight degrees absolute, then from the knowledge of these conditions that are successful in producing a change of state in hydrogen through the use of liquid air, we may safely predict that helium can be liquefied by following similar methods. If, however, the critical point is as low as six degrees absolute, then it would be almost hopeless to anticipate success by adopting the process that works so well with hydrogen. The present anticipation is that the gas will succumb after being subjected to this process, only, instead of liquid air under exhaustion being used as the primary cooling agent, liquid hydrogen evaporating under similar circumstances must be employed. In this case the resulting liquid would require to be collected in a vacuum vessel, the outer walls of which are immersed in liquid hydrogen. The practical difficulties and the cost of the operation will be very great; but on the other hand, the descent to a temperature within five degrees of the zero would open out new vistas of scientific inquiry, which would add immensely to our knowledge of the properties of matter. To command in our laboratories a temperature which would be equivalent to that which a comet might reach at an infinite distance from the sun would indeed be a great triumph for science. If the present Royal Institution attack on helium should fail, then we must ultimately succeed by adopting a process based on the mechanical

production of cold through the performance of external work. When a turbine can be worked by compressed helium, the whole of the mechanism and circuits being kept surrounded by liquid hydrogen, then we need hardly doubt that the liquefaction will be effected In all probability gases other than helium will be discovered of greater volatility than hydrogen. It was at the British Association Meeting in 1896 that I made the first suggestion of the probable existence of an unknown element which would be found to fill up the gap between argon and helium, and this anticipation was soon taken up by others and ultimately confirmed. Later, in the Bakerian Lecture for 1901, I was led to infer that another member of the helium group might exist having the atomic weight about 2, and this would give us a gas still more volatile, with which the absolute zero might be still more nearly approached. It is to be hoped that some such element or elements may yet be isolated and identified as coronium or nebulium. If amongst the unknown gases possessing a very low critical point some have a high critical pressure, instead of a low one, which ordinary experience would lead us to anticipate, then such difficultly liquefiable gases would produce fluids having different physical properties from any of those with which we are acquainted. Again, gases may exist having smaller atomic weights and densities than hydrogen, yet all such gases must, according to our present views of the gaseous state, be capable of liquefaction before the zero of temperature is reached. The chemists of the future will find ample scope for investigation within the apparently limited range of temperature which separates solid hydrogen from the zero. Indeed, great as is the sentimental interest attached to the liquefaction of these refractory gases, the importance of the achievement lies rather in the fact that it opens out new fields of research and enormously widens the horizon of physical science, enabling the natural philosopher to study the properties and behavior of matter under entirely novel conditions. This department of inquiry is as yet only in its infancy, but speedy and extensive developments may be looked for, since within recent years several special cryogenic laboratories have been established for the prosecution of such researches, and a liquid-air plant is becoming a common adjunct to the equipment of the ordinary laboratory.

PLANT PHYSIOLOGY IN THE HIGH SCHOOL.

BY C. R. BARNES.

Professor of Plant Physiology, The University of Chicago.

Ever since the natural sciences began to make their way into the curriculum of secondary schools, discussion as to the character and amount of instruction to be offered in each has formed an important topic in educational meetings and journals. Oftentimes these discussions have shown a strong bias on the part of the advocate of some particular subject, a bias due either to temperament or to special training, or to the nature of the work in which he is engaged. It is difficult for any one to eliminate such bias. It becomes increasingly difficult for one to do so as the field in which his immediate interest lies becomes more and more limited. Therefore the college teacher has oftenest evinced in such discussions a bias leading even to dogmatism. On this account, indeed, teachers in our secondary schools are tempted to discount or to reject without fair consideration the suggestions and advice of university men. I hope, however, that a short personal experience in a city high school, and a somewhat prolonged and intimate acquaintance with high schools of various grades of equipment and the usual limitations as to time, may enable me to write in moderation upon this topic, even though at present it forms the sole subject of my teaching.

It has been conceded generally that botany should have a place in the high-school curriculum, if not as a required subject, at least as an elective with zoölogy. The ease with which material may be secured and preserved, the absence of any repugnance to its handling, and the importance of plant activities in the world's work amply justify its inclusion. For a long time, however, botany was supposed to have as its most important function the acquainting of the pupils with the different kinds of flowers or trees which grew in a limited region. The whole training, therefore, was directed to such a knowledge of anatomy, and particularly of the technical descriptive terms, as would be useful to this end. In all the better schools, however, this limitation of study to the plants of a single group, with a somewhat trivial end in view, has

given way to a more comprehensive study of all the great divisions of plants, to gain the broader and truer conception of the plant kingdom as a whole. In doing this, laboratory work was at first overdone. Latterly, in the wise attempt to regain some features of the valuable training of outdoor naturalists, attention has been given to the relations of plants to the situations in which they grow and to one another, i. e., ecology. For such ecological study a physiological background is most important. But even where ecology has as yet made no way as an elementary subject, the claims of physiology to share with morphology have been pretty generally conceded. The reasons for this are evident enough. What the living being can do is interesting to almost every one, though the trouble necessary to see this is sometimes sufficient to deter the indifferent from the endeavor. But interest becomes awakened when to a knowledge of the structure of plants is added a study of the machinery in action. Physiology, furthermore, gives a kind of training not gained from morphology, and so enriches the whole subject.

If, then, there is a general course in botany, which we may assume to cover at least half a year, and preferably the whole year, what should be the character of that portion of it which is devoted to physiological work? In what relation and proportion should it stand to the other work? What ends should be kept in view?

Before answering these questions I may say by way of introduction that the work should be experimental. No mere study of a book about how plants grow or what they can do will be either interesting or valuable, except to the limited number whose interest in plants is already alive. A book may be necessary (in my judgment it is indispensable) as an accompaniment to the laboratory work, but the experiments themselves should be the main feature and the reading supplementary thereto.

Material for such a course can be grown readily in any greenhouse. Seedlings which can be quickly grown in the laboratory furnish the subjects of many an experiment. A few living plants, which may be derived from window gardens or from commercial greenhouses, will be necessary. One requisite, which in some of the smaller schools is more difficult to secure, is a room that is

not allowed to become cold at nights or on holidays. In such a place, however, if it be impracticable to heat the room from the main furnaces, a baseburner may be provided at small cost, which will obviate the difficulty.

The equipment necessary is also easily obtainable. The few chemicals, tubing, glassware, etc., are already at hand in the chemical or physical laboratory, or can be secured at small cost. In a correspondence course given here, which was more extended than would be suitable for a high school, it was found that the equipment needed for a single student working at home could be supplied for less than $15. I need hardly say that this would not be multiplied by twenty were a class of twenty working. The apparatus necessary is also limited in amount, and most of it can be constructed by the teacher and pupils at a small cost.[1]

I. In an elementary experimental course in plant physiology the study of the most fundamental functions only can be included. The experiments should illustrate how materials get into and out of the plant, a topic which will include the absorption of water and dissolved salts by the roots, of gases (O_2 and CO_2) by the leaves and transpiration. The conditions under which green plants make food should also be determined. Respiration, one of the most widely misunderstood functions of plants, should not be slighted. And finally, growth and movement, being manifested by obvious changes of form or position and readily modifiable by changing the external conditions, should be used to show the sensitiveness of plants and their responses to stimuli. There are a number of books from which experiments on these subjects can readily be selected. These may be modified to suit the conditions of the laboratory in which they are carried out, and will be both illustrative of important facts in plant life and deeply interesting to many students who otherwise would be indifferent.

II. The work in plant physiology may be presented either in connection with the study of morphology or may follow it as an independent division of botany. In my judgment it makes

[1]Lists of material and apparatus will be found in the appendix to my *Plant Life*, and admirable suggestions as to material and apparatus for a much more extensive course will be found in Ganong's *Laboratory Course in Plant Physiology*. Both are published by Henry Holt and Company.

little difference which of these two methods is pursued. Both have strong advocates, the former especially being the favorite of those who speak from a theoretical standpoint. It may be pointed out, however, that if one chooses to introduce the study of absorption after a consideration of the structure of the root, and to illustrate transpiration and photosynthesis after the examination of leaves, there can be no serious objection to it, provided certain dangers of omission are guarded against. Too often thus the leaves are left out of consideration as absorbing organs, absorption being associated wholly with the study of the roots. In reality, however, the absorption of gases by the leaves is of quite as much importance as any absorption by roots.

As to the amount of time to be devoted to physiology, it may fairly claim at least one-third, supposing that morphology and ecology share with it; and such a claim would certainly not be unfair if morphology alone were its companion. But no rigid relation of time is necessary or desirable.

III. The purpose of such a course in plant physiology should be primarily to stimulate interest in living things, and to cultivate power of observation; a secondary object should be to illustrate right methods of experimentation and inference. In such an elementary course one danger is to be guarded against most strenuously and continually, namely, the danger of permitting students to imagine that a single experiment, not rigidly quantitative, may be the basis of correct inference. They should be repeatedly warned that such experiments as they are making are merely illustrative of the way in which new knowledge can be gained. The fundamental rule of experimentation must be rigidly adhered to; namely, to have only one variable factor in the experiments. Control experiments under conditions identical except one are indispensable. It behooves the teacher of physiology also to be strictly on guard against the inculcation of bad physics. Much of our physiology, both plant and animal, suffers under this reproach today.

The question is often asked whether the experiments in such courses should be made quantitative. I should reduce the quantitative work in botany to a minimum, for the simple reason that training of this kind can be gained most easily and satis-

factorily in handling material less complicated than living plants. I believe firmly in quantitative experiments in elementary physics and chemistry. In the college or university quantitative work may properly be demanded in the extended courses in plant physiology.

Finally, I may touch the question, in what year of the course should such work be given? I refer to it not to discuss it, but to say that in my judgment it is not worth the time and energy which have been expended upon it. It is clear enough that a *logical* order demands physics and chemistry as a foundation for biology, but it is equally clear that other considerations beside logical order enter into the problem. The teacher who has any capacity for adaptation will be able to handle the botany in the first year or in the fourth. Naturally the two will be quite different in character. If physiology, therefore, comes before courses in physics and chemistry it will be necessary for the teacher to introduce such physical and chemical notions as are indispensable to an understanding of the experiments. This will limit his time and the character of his experiments. But they need not seriously interfere with such a course as I have suggested.

THE FEEDING HABITS OF FISHES.

BY C. JUDSON HERRICK,

Professor of Zoology, Denison University, Granville, O.

There is many a successful teacher of the natural sciences in our high schools who has not had a university training and who may possibly never have had the advantage of advanced work in any department of science, but who is nevertheless keenly alive to the truth of the familiar pedagogical maxim, that to be an inspiring teacher he must keep in touch with the most advanced movements of his subjects. While he cannot sweep the whole field of current research in all of his subjects, he can at least keep abreast of some small specialty and so vitalize his teaching to some degree with the real live blood of scientific progress. If possible he should from time to time contribute something to this specialty himself, some new fact or generalization which may be of value to others.

There are many fields in natural history which are still very accessible to observation and experiment and that, too, with no other equipment than a pair of good eyes and a patient, logical mind, if only one knows where to look for them. For instance, we are profoundly ignorant of the most common-place features of the daily life of most of the more lowly animals. The senses of fishes have been but little studied, and that with most diverse results. One author declares that fishes do not smell at all, another that some kinds find their food in that way alone, while a third affirms that fishes do not taste at all. Now, it will be possible (I do not say it will be easy) for any one who is free from bias and who has sufficient patience, ingenuity and critical ability, to devise simple experiments which will answer definitely some of these questions. The simplicity of some of these problems may be illustrated by the following experiments in my own recent experience.

In the course of a series of papers which have been running through *The Journal of Comparative Neurology* during the past three or four years, I have worked out the structure and nerve supply of the sense organs in a number of kinds of fishes. Taste buds similar in structure and nerve supply to our own are always found abundantly in the mouth of fishes. That they do taste with these organs can be easily shown by experiment. Thus, if a fish is fed with bits of soft meat, he swallows them instantly; but if now bits of gelatine well softened in cold water are substituted for the meat, the pieces may be taken into the mouth, but they are at once rejected. The gelatine may be colored to look like the meat and to the sense of touch it is exactly the same, but the instant it gets into the mouth the discrimination is made.

Now, in some fishes (but not in all) similar sense organs, known as "terminal buds," are found outside the mouth—all over the skin of the body in the cyprinoids, or carp tribe, on the barblet and free rays of the ventral and dorsal fins in the ganoids, or cod tribe, and on the barblets and very abundantly all over the body in the siluroids or cat-fish tribe. In all of these cases I have traced out by a microscopical method the innervation of these cutaneous organs and I have found that, however devious the path by which their nerve fibers pass back to the brain, they always reach a com-

mon center, which is also the center which receives the nerve fibers from the undoubted taste buds in the mouth. This, of course, is strong presumptive evidence that the terminal buds of the outer skin have a gustatory function; but presumptions are not satisfactory in scientific work when facts are obtainable.

To test this hypothesis then, the feeding habits of a lot of young cat fishes were studied. The cat fishes never seem to see a bit of meat thrown into the water nor to find their food by the sense of sight at all, but if a barblet or the body anywhere touches such a piece of meat the fish snaps it up instantly. In swimming they constantly drag the bottom with the barblets for this purpose. If the body is touched anywhere with a bit of meat on a long wire, the meat is taken the same way; but if the fish is touched with a wisp of white or red cotton or other tasteless thing, he may turn and touch it with a barblet once or twice, but after a few such experiences the fish pays no more attention to it. If a jet of meat juice is squirted against the side of the body of the fish under water with a fine pipette, the fish makes the same reaction as he would if touched by a piece of meat; but if a jet of water is used he pays no attention to it. These and many similar experiments indicate that the cat fishes can taste not only in the mouth, but also over the whole body surface and particularly with the barblets, and that this sense is the one chiefly relied upon in finding their food.

This is by no means the case with all fishes, for most of them undoubtedly find their food chiefly by the sense of sight, and, though I have tested in the manner described above a considerable number of species, I do not get these characteristic gustatory responses from the outer skin except from fishes which have the terminal buds in the areas stimulated. I have worked also with the tom cod, hake and other fishes of the cod tribe, with essentially the same results.

Of course in these reactions there is generally both a gustatory and a tactile reaction involved. The parts are supplied with both kinds of nerves and I find in general that where the terminal buds are very abundant, as in the cat fish, the gustatory element is more important, while in the tom cod, where the terminal buds are present in less numbers, the tactile element plays a much

larger part in the reflex of seizing food. It may properly be asked whether the sense of smell plays any part in these reactions, and to test this I destroyed the olfactory nerves of both sides in a tom cod by cutting them off. After recovery from the operation he was placed in the same tank with normal specimens and I could observe no difference in their behavior, and hence conclude that these responses were independent of any function associated with the nose of the fish.

The reader will observe that these experiments involve the use of practically no apparatus. They are not, however, so simple as may appear on the surface, since to be of value every observation must be controlled by repetitions from as many points of view as possible, and no small amount of patience is required to get the animals to feel at ease and react to experimental conditions in a perfectly normal way. It is, nevertheless, intensely interesting work and well repays the observer for any expenditure of time and effort. My own experiments will be reported upon at length in the forthcoming volume of the *Bulletin of the U. S. Fish Commission*, to which the reader is referred for further details. There are scores of similar problems connected with the life of the fishes alone, to say nothing of the other lower animals, and real facts, acquired at first hand, thoroughly controlled and digested, are the foundations of all sciences.

MATTER AND METHOD IN PHYSICS TEACHING.*

BY R. H. CORNISH.

First Assistant, Wadleigh High School, New York City.

I shall not, at this late day, make any special plea for the sciences in general or for physics in particular. These studies find a place more or less conspicuous in the program of every high-school in the country. The endowed academies and private schools all make provision for science teaching. The latest catalogue of Phillips Andover Academy, the oldest endowed academy

*Abstract of an address delivered April 18, 1902, before the Department of Pedagogy, Cornell University.

in New England, and for more than a hundred and twenty years a great classical preparatory school, places physical geography as a required study in its first year and physics, chemistry and botany in the fourth year of its classical course. Many colleges permit the substitution of physics or chemistry for Greek or a modern language in their entrance requirements. To say that the sciences are everywhere accepted as equivalent to languages and mathematics as college entrance requirements would be stating more than the truth. No such claim is made. But that they are everywhere recognized as one of the great instruments of culture worthy of serious attention, and consequently to be provided for both by program makers and by those who furnish the material equipment, is to state the simple truth.

The questions now in dispute are not as to the wisdom of including science in the secondary school program nor how can it justify itself practically or pedagogically. Those questions have been answered. The questions now in dispute are such as these: (1) What sciences shall be prescribed and what shall be optional? (2) What methods of instruction shall be followed? (3) In what order shall the different branches of science be taken up? (4) What shall be attempted in a one-year's course of any particular branch? These questions all have many different answers. If you were engaged in arranging a course of study for a school or system of schools, the first and third questions would demand immediate answers, viz.: In what order shall the sciences be taught and what shall be taught?

In endeavoring to answer these questions it is to be noted that science (by which I mean objective knowledge, knowledge that exists outside the mind) is one, and that it is only for our convenience that we divide it up into parcels and label these parcels physics, chemistry, biology, geology, and that these parcels are every year growing larger and larger with astonishing rapidity. Also since all science is one, its different branches are closely related, and mutually dependent. The terms physics, chemistry and all the rest do not denote sharply divided territories like the towns of a county, but regions of knowledge which overlap other regions. Chemistry and physics have a theoretic distinction clear and sharp, but practically they are closely dependent and related.

Every physics teacher must know something of chemistry, while physical chemistry is a most important part of general chemistry. Biology includes many problems of both physics and chemistry, while physical geography is very largely concerned with finding out how physical, chemical, and biological forces are modifying the earth's surface.

Prof. T. C. Chamberlain says that each science depends upon every other science; hence each science should logically precede every other in the course of study. This paradox is only an emphatic way of stating the difficulty of the problem. The moral of all this for the teacher of science is the very obvious one that in order to be successful in one an acquaintance with all is very desirable. The larger his knowledge, the better for the teacher.

This question of what is the proper sequence of science studies is one of the most disputed and most disagreed about that we have to discuss. For example, Prof. Woodhull, of the Teachers' College, New York, argues earnestly for placing chemistry in the first year of the high-school course. He claims that both logical arrangement and the needs and interest of the pupil are favored by this method. The simplicity of the apparatus needed, its ease of manipulation, and inexpensiveness he urges as favorable to his plan. Such a course as he describes would, I am sure, be a valuable one. I should like to see such a course forming a part of a larger course for the first year. I know of very few schools, however, that adopt this plan. The Committee of Ten places physical geography in the first year; physics and botany or zoölogy in the second; astronomy and meteorology in the third, and geology, or physiography, or anatomy, or physiology, in the fourth.

This lack of agreement as to sequence is unfortunate. Any arrangement will find objectors and any arrangement may, with judicious teachers, produce good results. There is no doubt that every science has an elementary and an advanced stage. Physics, for example, taught to first-year pupils, must be presented in a very different way from physics taught to third or fourth-year pupils. The latter have the requisite mathematical knowledge and maturity of mind to profit by an advanced method of presentation. They have also, presumably, studied for one or two years some other branch of science. This has had its effect in widening the

mental horizon. The same is true of other branches. Any first-year science would necessarily be narrower than the same science would be if presented in the last year. In order to meet this desire to have some facts in hand when the student begins the serious study of any particular branch of science it has always seemed to me that a course of physiography, in the English sense of the word, would be a most desirable plan. This means a systematic course in elementary science of all kinds, elementary physics, chemistry, geology, botany, astronomy. Such a course should be followed by a serious and detailed study of at least one branch of science in each of the succeeding years of the course. If nature study has been systematically presented during the pupils' primary and grammar school course, especially during the 7th, 8th and 9th grades, then such an introduction as I have described would not be necessary, and the pupil might at once take up some branch of science in a more detailed and thorough manner. In the new program of study for the high-schools of the Boroughs of Manhattan and Bronx the arrangement for the sciences is as follows: First year, biology, required in all courses, 4 hours per week. Second year, physiography or chemistry in the scientific course; third year, physics, required in all courses, 5 hours per week. Fourth year, biology, chemistry, astronomy and physiography, elective, each, 4 hours per week.

The course of study for a large city, like New York, is a very important matter. It will affect very soon not less than 10,000 high-school pupils; if extended to all the boroughs, probably twice that number. Several things may be noted with reference to the science studies of this course: (1) All the sciences which are included, whether required or elective, occupy one year, 4 or 5 periods per week. Thus is recognized the wisdom of abandoning the half-year, or 14-week, courses in science, which have been so popular in the past. (2) The biological sciences represented by biology and physiology, and the physical sciences, represented by physics, are required of all pupils in all courses. All teachers of science must approve of these two facts. This arrangement gives to two very important subjects proper recognition and value. (3) Physiography, or physical geography, a representative earth science, is required in one course only and even there it competes

with chemistry for recognition. This I believe unfortunate and I wish that this branch had been required in all courses except the classical.

That arrangement, with the recognition of biology and physics which has been made, would have left the science teachers with little to ask, and would have furnished a wise and defensible program upon which all science teachers could unite, for it is to be noted (4thly) that astronomy, advanced biology, chemistry, physiography (and to this list we hope to add advanced physics) are offered as elective studies of the fourth year. This latter point will, I think, meet with general approval.

The whole arrangement, therefore, with the exception I have noted with regard to physiography, disposes in a fairly satisfactory manner of the vexed questions—what sciences shall be taught, what shall be elective and what required? There is not time in this discussion for stating the reasons for making certain subjects required and others elective, but the reasons are hinted at in the use of the phrases, biological sciences, earth sciences, and physical sciences.

For myself, I do not think that the discussion as to the order in which the various sciences shall be taught is very interesting nor very important. The main thing is to have whatever science comes first properly taught; taught so that it shall be stimulating to the observing powers; taught with due regard to the student's stage of progress, and so taught that it shall furnish a real introduction to a scientific method. And with a competent, thoughtful, enthusiastic teacher this will be done.

I have no objections, therefore, to Mr. Woodhull's having chemistry in the first year of the Horace Mann school, nor to Mr. Peabody's having biology in the first year of the high schools of Manhattan and Bronx, nor shall I object to your own Prof. Wilder's introducing the laboratory study of calves' brains into the grammar schools of Ithaca. With his mastery of the subject and his great enthusiasm I have no doubt that that also would be profitable.

The relation of physics to mathematics is more close and dependent than the relation of physics to any inductive science. The laws of physics are statements of the relations existing between two or more variable quantities. The highest aim of the physicist

is to discover the relations existing between the varying quantities which are before him and which change together. Besides this exact and mathematical relation which the physicist aims to discover and state in the briefest and most exact language, the elementary study of physics constantly uses geometric ideas, terms and definitions, and to a smaller extent the processes of elementary algebra. These should be thoroughly embedded in the student's mind, if he is to make the most progress and get the most from the study. The more the pupil knows of arithmetic, algebra and geometry, the easier becomes his mastery of physics. This knowledge of elementary mathematics cannot be too thorough or complete. This use of geometry and geometric ideas is most marked in mechanics and optics. Hardly a step can be taken in the study of light without running against geometric terms and propositions. It has already been said that the laws of physics are statements of the relations existing between two or more variables. These statements use the language of variation for their expression. But variation is only a condensed proportion and proportion is an equality of ratios. Therefore from the standpoint of the physics teacher ratio, proportion and variation are the most important topics which the algebra contains.

If physics is to have its full value in mental development, then the pupil should have all the mathematical training and mental maturity possible. The science of physics has two foundation stones: mathematics and experiment. One is as important as the other. If it is mathematical it is also experimental and inductive. Those generalizations which we call laws are in every case statements of what would be true if the conditions were ideal, and this is never true. On account of this dependence of physics upon mathematics, all teachers of physics urge postponing its formal study as late as possible in the course. The new course of study in New York, to which I have referred, places physics in the third year after plane geometry and elementary algebra have both been studied.

I shall not undertake to define nature study for you, as that has been done by Prof. L. H. Bailey in the twenty-fifth lecture of this course. He says: "The proper objects of nature study are the things one oftenest meets. Today it is a stone, tomorrow

it is a twig, a bird, an insect, a leaf. The child or even the high-school pupil, is first interested in things which do not need to be analyzed or changed into unusual forms or problems. Therefore, problems of chemistry or physics are for the most part unsuited to early lessons in nature study." I suspect he is right and that objects of natural history are in general best to begin with in the informal study of science. Observational lessons on clouds, rain, dew, running water, ice, frost, snow, are perhaps next in simplicity. The informal study of very many of the facts and phenomena of physics and chemistry might next be taken up. This simple, non-mathematical observational method of studying physics is, it seems to me, a part of nature study, and appropriate to grades below the high-school. To understand what takes place when a kettle boils, when a candle burns, when the dew "falls," when the rainbow appears, requires considerable intelligence and thought; more, I think than comparing the forms of leaves or noticing the habits of an animal. Therefore physics and chemistry should come last in the nature study course of the grammar school. But that it should be included in the elementary school course, I firmly believe. Prof. Bailey says: "The only way to teach nature study is with no course laid out, to bring in whatever object may be handy, and to set the pupils looking at it." It seems to me, however, that if any progress is to be made in physics or chemistry as a branch of nature study, there must be much careful planning on the teacher's part. Many helpful books have been written and much thought given to planning this sort of work for grammar schools. For example, in the elementary schools of Montclair, N. J., a course of combined physics and chemistry is a part of the work of the last three years in the 7th, 8th and 9th grades.

Some grammar schools have attempted more than this. The Cambridge (Mass.) Grammar Schools several years ago adopted a course elaborated by Prof. E. H. Hall, of Harvard, and described in his little book called "Lessons in Physics." This course comprehended individual laboratory work by the pupil and much demonstration work by the teacher. It occupied one hour per week throughout a year, and included the performance of twenty-seven individual laboratory exercises.

(*Concluded in January.*)

A DIAGRAM ILLUSTRATING UNIFORMLY ACCELERATED MOTION.

BY HERMAN D. STEARNS.

Associate Professor of Physics, Leland Stanford University.

Fig. 1 contains three right triangles. The sides *AB, BC* and *BD* are represented arbitrarily by the symbols $\frac{2}{a}$, *S* and *T*. The geometry of the figure shows that

$$S = \tfrac{1}{2} a T^2 \qquad (1)$$

Let the points *A* and *B* be fixed: $\frac{2}{a}$ is then fixed. Let the point *D* start at *B* and move uniformly in the direction *BD* with

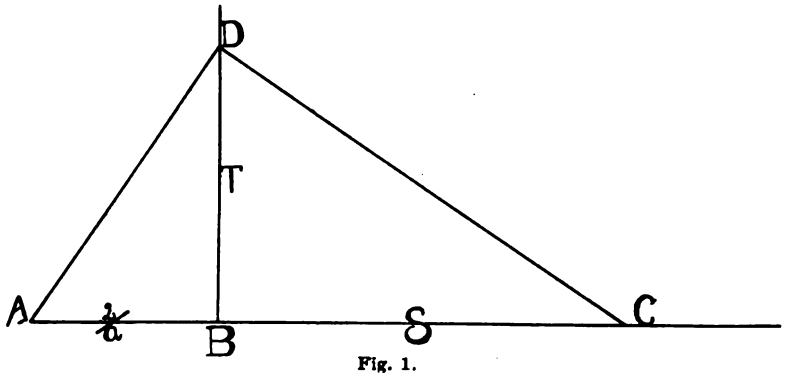


Fig. 1.

unit velocity. *BD*, measured in units of length, is then numerically equal to the time *T* measured in seconds and the purpose of the symbol *T* is plain.

During the motion of *D* let the point *C* move in the direction *ABC* so that the angle *ADC* shall always be a right angle. To fulfill this condition *C* and *D* must leave *B* at the same instant and *T* represents the time required by the point *C* in moving the distance *BC* or *S*.

Equation (1) now expresses the space passed over by the point *C* in terms of the time *T* and a fixed quantity *a* and the equation is seen to be that of uniformly accelerated motion, the rate of acceleration being *a*.

Two simple cases will serve for illustration:

Suppose that *A* is a powerful source of light and that a uni-

formly moving car D carries a mirror that rotates in such a way as to reflect a beam of light from A at right angles to AB and against a wall BC. The spot of light will move along the wall with uniform acceleration.

Suppose, again, that A in Fig. 2 is a knife edge and that a carpenter's square moves so that one arm slides against A while the vertex of the right angle moves uniformly along BD. If the other arm drives a particle C along a grooved track BC, C will move with uniform acceleration.

In both these cases the rate of acceleration will be a if D move

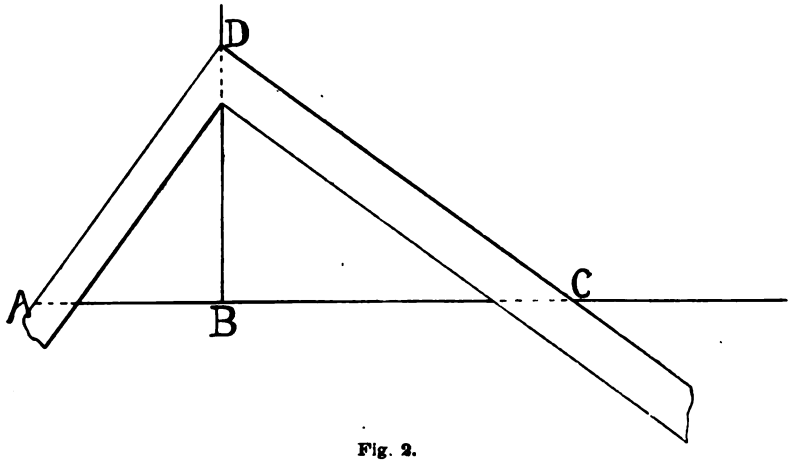


Fig. 2.

with unit velocity. If D move with any other uniform velocity the rate of acceleration will be proportional to a.

If this geometrical method were used in presenting the subject of uniformly accelerated motion to a student for the first time, it would be necessary to show that equation (1) represents such motion. The usual algebraic method is to express the mean velocity $\bar{v}$ during the time $T_2 - T_1$ by the equation

$$\bar{v} = \frac{S_2 - S_1}{T_2 - T_1} = \tfrac{1}{2} a \frac{T_2^2 - T_1^2}{T_2 - T_1} = a \frac{T_2 + T_1}{2}$$

Hence,

$$\bar{v} = a T, \qquad (2)$$

where T is midway between T_1 and T_2.

Since the same value is obtained for $\bar{v}$ for all values of

the interval $T_2—T_1$ if the mid-point T remain unchanged, it follows that the mean velocity $\bar{v}$ is the actual velocity v at the instant T.

Hence,

$$v = a\,T. \qquad (3)$$

Equation (3) contains the definition of uniform acceleration.

However, equations (2) and (3) may be approximately obtained from the diagram without the use of algebraic methods.

Draw Fig. 3 as accurately as possible and locate a point T midway between two points T_1 and T_2. Locate the corresponding points S_1 and S_2. Measure the lines $S_2—S_1$ and $T_2—T_1$ and find the value of $\bar{v} = \frac{S_2—S_1}{T_2—T_1}$

Proceed in the same way with other values of T_1 and T_2, keeping the mid-point T unchanged. This will lead to the determina-

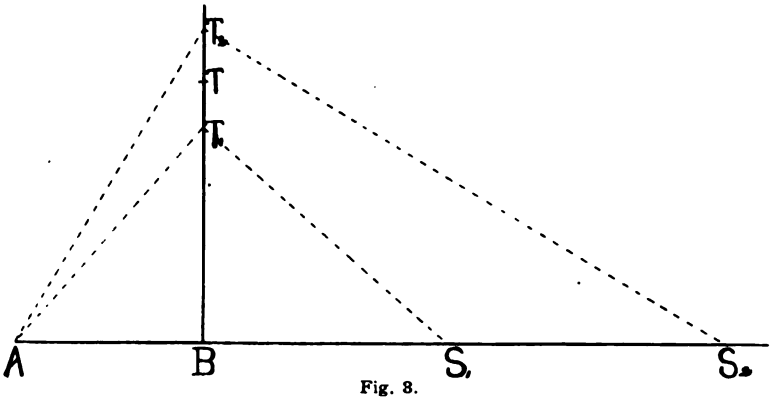


Fig. 3.

tion of v. Now take the other positions for T and proceed as before Equations (2) and (3) will soon appear if the drawing and measuring are at all accurate and this work will make clearer the algebraic solution.

The diagram is applicable, of course, to any units of length and of time, and any rate of acceleration can be represented by making the line AB the proper length.

For the case of a freely falling body the decameter (ten meters) and the second are convenient units.

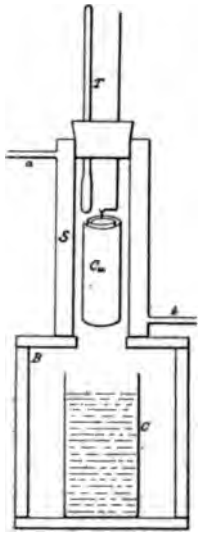
THE USE OF THE JOLLY BALANCE IN CALORIMETRY EXPERIMENTS.

BY HARVEY L. CURTIS.

Instructor in Science, Decorah (Ia.) Institute.

The object of this article is to show a method of determining the specific heats of substances as well as the heat of fusion and the heat of vaporization without determining the modulus of the Jolly balance. In order to make the student independent in his results, the specific heat of copper is determined first. The calorimeter is made of sheet copper, using as little solder as possible. One 2½ inches in diameter and 4 inches high is a very convenient size.

For heating the copper coil, I use the steam jacket, the principal features of which are shown in Fig. 1. This has been in use for many years, but it not described in any high school laboratory manual with which I am familiar. It consists of two cylinders of sheet metal, one within the other, and the space between air-tight except for the tubes *a* and *b*. Such a jacket will be made by any tinner for a few cents. The tube *a* is connected to some source of steam and the condensed water is carried off through *b*. The inner cylinder is closed at the top by a two-hole rubber stopper through which pass the thermometer *T* and a small copper wire, which suspends the coil *Cu*. The coil should weigh from 200 to 300 grams. The jacket is placed on a box *B*, which contains the calorimeter *C*, nearly filled with water. There is a hole in the top of the box, but the jacket is placed over it only while the coil is being lowered into the calorimeter. This should not be done until the temperature of the coil becomes stationary.



Then as the quantity of heat lost equals the quantity of heat gained $m_1 s(t_1 - t) = m_2 (t - t_2) + m_3 s (t - t_2)$ where m_1, m_2, and m_3 are the masses of the coil, the water, and the calorimeter, respectively; s, the specific

heat of copper; t_1, the temperature of the coil; t_2, the temperature of the calorimeter and water; and t, the resulting temperature. But if a_1, a_2, and a_3 represent the stretching of the spring of a Jolly's balance due to the coil, the water, and the calorimeter, respectively, and x the modulus of the balance, then $a_1x = m_1$, $a_2x = m_2$, $a_3x = m_3$. Substituting in the first equation:

$$a_1xs(t_1-t) = a_2x(t-t_2) + a_3x(t-t_2)$$

In solving, x disappears, and

$$s = \frac{a_2(t-t_2)}{a_1(t_1-t)-a_3(t-t_2)}$$

In determining the specific heat by this method it is necessary then to find the stretching for the coil, the calorimeter, and the water. This will require a heavier spring for the Jolly balance than is ordinarily used. It may be made of No. 18 spring brass wire, closely wound on a 3/8-inch rod, and should be about two or three feet long.

In determining the heat of fusion of ice, the same principle is used. If a_1, a_2, and a_3 represent the stretching due to the ice, the water, and the calorimeter, respectively; t_1, the original temperature of the water; t, the resulting temperature; and L the heat of fusion of ice, then $a_1xL+a_1xt = a_2x(t_1-t) + a_3xs(t_1-t)$, where x is the modulus of the balance and s the specific heat of copper previously determined. Solving,

$$L = \frac{(a_2-a_3s)\ (t_1-t)}{a_1} - t$$

The heat of vaporization may be determined in the same way as the last by substituting steam for ice.

In the last two, it is advisable to make corrections for radiation as indicated in Chute's Physical Laboratory Manual. In the first corrections for radiation are usually unnecessary.

The results obtained have been quite satisfactory, considering that we were compelled to use very ordinary thermometers. For the specific heat of copper three successive results were 0.095, 0.091 and 0.096. For the heat of fusion of ice like results were 78, 77.5 and 80.4. A part of these results was obtained by the students. For the heat of vaporization of water the only results so far obtained are 542.3, 527.8, and 543.3.

The method has little value for those schools which have

a sufficient number of balances capable of carrying as heavy a load as these experiments demand. It does afford an inexpensive method to those schools which are lacking in balances that will carry a heavy load.

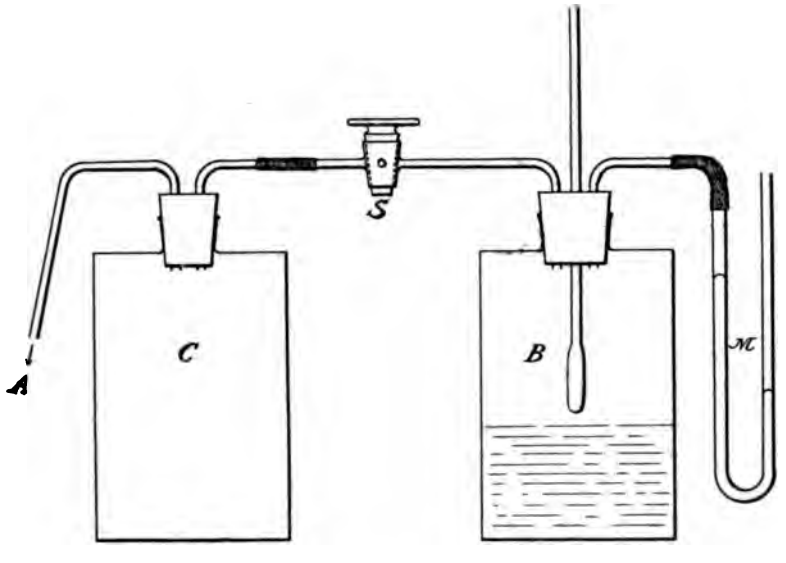
AN APPARATUS FOR DETERMINING THE RELATION BETWEEN PRESSURE AND BOILING POINT.

BY N. F. SMITH.

Professor of Physics, Olivet College.

The following simple apparatus has been found to give very satisfactory results in the hands of elementary students of physics.

A copper boiler B is provided with a stop-cock S to regulate the escape of steam, and an opening in the top into which a



rubber stopper can be tightly screwed. The rubber stopper carries a thermometer and a glass tube leading to a manometer M attached to the wall. A rubber tube leads from the stop-cock to another copper vessel C and thence to an aspirator A, which rapidly exhauts the air in B and C. The vessel C was introduced to equalize the pressure which, on account of variations in the water

pressure, was found to fluctuate slightly, and also to catch water which sometimes was forced back from the aspirator.

Under these conditions water in *B* can be made to boil under a pressure of from 20 to 30 cm. As soon as pressure and temperature have become constant, both are recorded. The stop-cock *S* is then partly closed so that steam is generated in the boiler faster than it escapes and the pressure thereby increased. By regulating the stop-cock the pressure can be kept constant at any point desired and readings of temperature made for every four or five centimeters increase in pressure. After the pressure becomes equal to that of the atmosphere the tube is disconnected from the aspirator and the pressure carried up as high as the strength of the boiler and the graduations on the thermometer will safely allow.

A range of pressure from about 26 cm. to 115 cm., corresponding to a range of temperature from about 70° to 110° was easily and safely attainable by the student and the data when platted gave a very good curve, bringing out the relationship between the vaporization and temperature of a liquid in an excellent manner.

A SKELETON TELESCOPE.

BY E. C. WOODRUFF.

Instructor of Physics, LaGrange (Ill.) High School.

"Is that all there is to a telescope?" This question was asked by a pupil of average brightness when he first saw the apparatus here to be described. The work in class on the text in light had evidently only increased the mystery of the telescope to him. The question constitutes half the argument for the writing of this article. The importance of the experiments on images in telescopes and microscopes (No. 131 in Nichol, Smith and Turton's "Manual" and No. 82 in Ayres' "Manual") is emphasized by the same argument. The apparatus is intended to furnish a definite instrument for these experiments so as to avoid the use of pick-up pieces from the outfits of other experiments. It is also intended to be used in mirror and scale work (vid. SCHOOL SCIENCE, Vol. II., p. 94,

April, 1902), where conventional reading telescopes are beyond the reach of the school. The design was originally in response to a definite request for such a device.

The construction is as follows (Fig. 1): *O* is an ordinary plano-convex lens of about 20 cm. focal length. *E* is such a double-convex lens as jewelers use—mounted, perhaps, in a flaring rubber tube *T*, and of about 6 cm. focal length. Used as a telescope the combination will have a magnifying power of about 3 diameters. *B* is a base board, 28x5x2 cm. *L* is an upright, 5x5x2 cm., screwed to *B* and carrying the eye-piece *E*. *S* is a similar upright carrying the object-lens *O*, but fastened to the side-bars *b*, one on either side of *B*, and so free to slide along the base. *C* is a cross-bar resting on top of *B* and holding the two bars *b* together. *W* is a wire, one end fastened to *B*, pointed at the other end, and bent at right angles

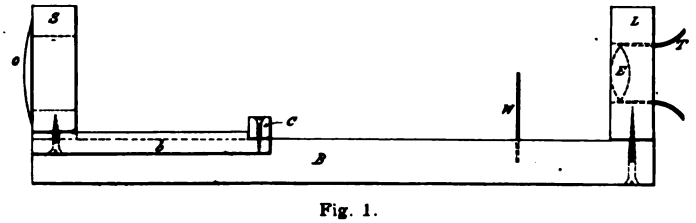


Fig. 1.

so as to bring the point horizontally into the center of the field of *E* to serve as a cross-wire.

Turn the instrument end for end and you have a compound microscope. The experiments are performed just exactly as directed in the Manuals.

Of course, when used as a reading telescope the definition is very good only in the center of the field, but that is all that is necessary. A dark cloth thrown over the instrument makes reading a little easier.

The simplicity of the arrangement appeals to the pupil. Many pupils will no doubt construct such instruments for themselves from reading glasses and hand magnifiers found lying around in most every house, thereby deriving considerable benefit.

pressure, was found to fluctuate slightly, and also to catch water which sometimes was forced back from the aspirator.

Under these conditions water in *B* can be made to boil under a pressure of from 20 to 30 cm. As soon as pressure and temperature have become constant, both are recorded. The stop-cock *S* is then partly closed so that steam is generated in the boiler faster than it escapes and the pressure thereby increased. By regulating the stop-cock the pressure can be kept constant at any point desired and readings of temperature made for every four or five centimeters increase in pressure. After the pressure becomes equal to that of the atmosphere the tube is disconnected from the aspirator and the pressure carried up as high as the strength of the boiler and the graduations on the thermometer will safely allow.

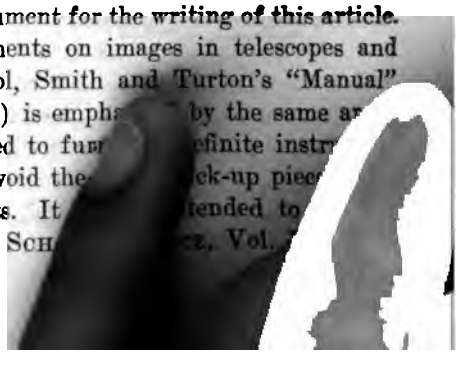
A range of pressure from about 26 cm. to 115 cm., corresponding to a range of temperature from about 70° to 110° was easily and safely attainable by the student and the data when platted gave a very good curve, bringing out the relationship between the vaporization and temperature of a liquid in an excellent manner.

A SKELETON TELESCOPE.

BY E. C. WOODRUFF.

Instructor of Physics, LaGrange (Ill.) High School.

"Is that all there is to a telescope?" This question was asked by a pupil of average brightness when he first saw the apparatus here to be described. The work in class on the text in light had evidently only increased the mystery of the telescope to him. The question constitutes half the argument for the writing of this article. The importance of the experiments on images in telescopes and microscopes (No. 131 in Nichol, Smith and Turton's "Manual" and No. 82 in Ayres' "Manual") is emph[illegible] by the same ar[illegible] ment. The apparatus is intended to fur[illegible] finite instr[illegible] for these experiments so as to avoid the [illegible] ck-up piec[illegible] the outfits of other experiments. It [illegible] tended to [illegible] in mirror and scale work (vid. Sch[illegible] z, Vol. [illegible]



April, 1902), where conventional reading telescopes are beyond the reach of the school. The design was originally in response to a definite request for such a device.

The construction is as follows (Fig. 1): *O* is an ordinary plano-convex lens of about 20 cm. focal length. *E* is such a double-convex lens as jewelers use—mounted, perhaps, in a flaring rubber tube *T*, and of about 6 cm. focal length. Used as a telescope the combination will have a magnifying power of about 3 diameters. *B* is a base board, 28x5x2 cm. *L* is an upright, 5x5x2 cm., screwed to *B* and carrying the eye-piece *E*. *S* is a similar upright carrying the object-lens *O*, but fastened to the side-bars *b*, one on either side of *B*, and so free to slide along the base. *C* is a cross-bar resting on top of *B* and holding the two bars *b* together. *W* is a wire, one end fastened to *B*, pointed at the other end, and bent at right angles

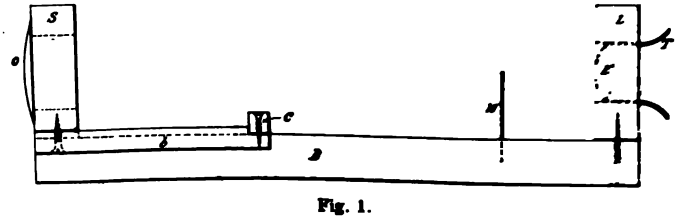
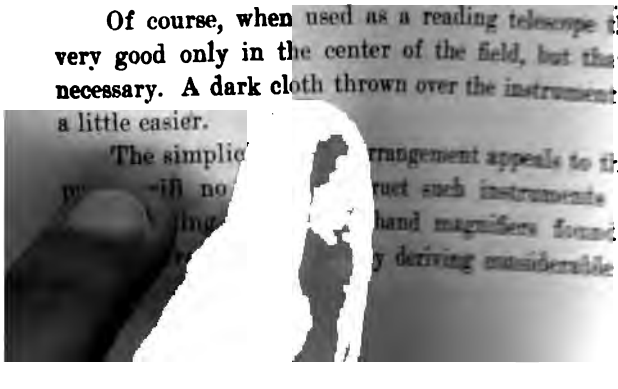


Fig. 1.

so as to bring the point horizontally into the center of the field of *E* to serve as a cross-wire.

Turn the instrument end for end and you have a compound microscope. The experiments are performed just exactly as directed in the Manuals.

Of course, when used as a reading telescope the field of *E* is very good only in the center of the field, but that is all that is necessary. A dark cloth thrown over the instrument makes reading a little easier.



The simplicity of the arrangement appeals to the pupil. Every pupil should construct such instruments. Pocket magnifiers found in stores are usually deriving considerable profit

EXAMINATION OF BAKING POWDERS.

BY WARREN RUFUS SMITH.

Department of Chemistry, Lewis Institute, Chicago.

Nothing interests the student in chemistry more than an opportunity to apply the knowledge gained in the laboratory to something with which he is already familiar. Unfortunately most of the commonest substances are of such complex constitution and composition that the elementary student can do little with them. I have found, however, that ordinary baking powders offer a field which is not beyond the skill and comprehension of the beginner. Below are some directions which students have used with satisfactory results. Of course these processes are not new and doubtless they can be improved. I offer them here simply to suggest to other teachers the possibility of similar experiments.

QUALITATIVE EXAMINATION OF BAKING POWDERS.

$NaHCO_3$	$KHC_4H_4O_6$	$KHSO_4$
$CaHPO_4$	$CaSO_4$	$KAl(SO_4)_2$
Starch	(NH_4) compounds	

1. STARCH. Treat a small amount of baking powder with cold water. Filter. Wash the undissolved residue, and boil it with water. Allow the resulting solution to cool and add a few drops of a solution of iodine in potassium iodide solution.

Blue or black color indicates starch.

2. TARTRATES. Treat with a small quantity of cold water. Filter, wash the residue with cold water. Evaporate filtrate and washings to dryness. Heat a small portion of the dry material. If tartrates are present, it will char and give the odor of burnt sugar. Moisten a small amount of the dry material with conc. sulphuric acid and heat.

Blackening indicates tartrates.

3. SULPHATES. Boil a small quantity of the powder with conc. hydrochloric acid till all dissolves. Dilute and add barium chloride solution.

White precipitate indicates sulphates.

4. PHOSPHATES. Dissolve a small quantity of the powder in conc. nitric acid, dilute with two volumes of water. Put ¼ inch of ammonium molybdate solution in a test tube and add a few drops of the nitric acid solution. Warm and allow to stand.

A yellow precipitate indicates phosphates.

5. CALCIUM. Treat with dilute hydrochloric acid. Filter, add ammonium hydroxide in excess (testing with litmus), then add a very slight excess of acetic acid (litmus), boil, filter if necessary and add ammonium oxalate.

White precipitate indicates calcium.

6. ALUMINUM AND AMMONIUM. Boil with sodium hydrate solution in a porcelain dish. If ammonium salts are present ammonia will be given off and can be recognized by its odor and effect on litmus. Filter the solution and acidify the filtrate with hydrochloric acid and then add ammonium hydroxide till alkaline.

White floating precipitate indicates aluminum.

DETERMINATION OF THE AVAILABLE CARBON DIOXIDE IN BAKING POWDER.

Arrange apparatus as in Fig. 1. *A* is a separatory funnel, *C* a dry 500 cc. flask, *D* a dry 2-liter acid bottle, *E* a liter flask filled with water, *F* a beaker, *G* a dry liter flask, and *H* a rubber tube. The rubber stoppers should be well greased. Weigh about 5 grams of powder in a test tube. Turn the powder into the flask *C* and weigh the tube again to get the weight of powder used. See that the tube *H* is entirely filled with water. Open the stopcock *B* and hold *F* so that the level of water in *F* and *E* is the same. Without altering the position of *F* close the stopcock *B* and pinch the rubber tube *H* tightly with the fingers. Remove *F* and replace it with the empty weighed liter flask *G*. Place *H* in the flask and release the pressure on *H*. Measure 100 cc. of water and put it in the separatory funnel *A*. Allow this water to run into *C*, closing the stopcock *B* just as the last of the water goes through and before any air enters the tube of *A*. Heat the flask *C* gently until its contents boil slowly for a few moments. If the contents of the flask foam, take away the burner before

the foam reaches half way up the flask. Allow to cool a little and then heat again. Do not let any foam reach the tube *I*. It has usually been boiled enough as soon as the tube *I* is hot from the steam in it. Allow the whole to cool to the temperature of the room, hastening the cooling, if convenient, by cooling *C* by setting a dish of cold water under it in place of the wire gauze. After *C* has apparently reached the temperature of the room allow the whole apparatus to stand for at least ten minues without further heating or cooling. Observe the temperature and the height of the barometer. Hold *G* so that the water in it is at

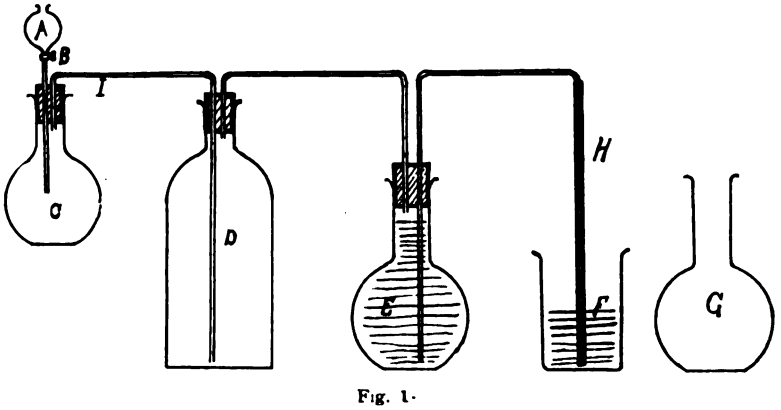


Fig. 1.

the same level with that in *E*. Pinch *H* tightly with the fingers and take away the flask *G* and weigh the water in it. This volume (minus the 100 cc. of water added) equals the volume of CO_2. Reduce this volume to standard conditions.

Determine the weight of CO_2 obtained. One liter of CO_2 under standard conditions weighs 1.977 g. Calculate the percentage of available CO_2 in the baking powder.

The greatest chances for errors lie in not having the apparatus tight and in not allowing to cool to the temperature of the room.

A COMBINED FILTER-FUNNEL AND BEAKER.

BY GEORGE GEORGE.

Headmaster of the Sutherland Technical Institute, Longton, Staffs., England.

In Fig. 1 is shown a piece of apparatus which the writer has found very serviceable in large classes in elementary chemistry, especially in experiments where precipitation, filtration and weighing are combined, as, for example, where a comparison is made of the weights of different metals replaced from their salts by a certain weight of another metal. As can be seen from the sketch, it is really a large thistle-funnel, *A*, having a bulb *B* and a short stem *C*, which can be closed by means of a piece of

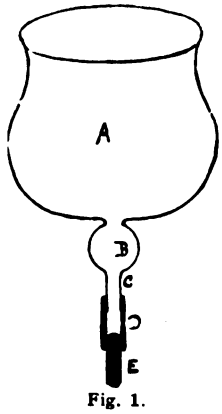


Fig. 1.

rubber tubing *D* and glass rod *E*. The diameter of the large bulb *A* is from 6 to 8 cm., its capacity about 100 cc., and its weight less than 20 g. These can be made by anyone rather skilled in glass blowing.

Use of the Funnel.—Suppose the experimental problem to be: "To determine the equivalent of silver by finding the weight of the metal displaced from a solution of silver nitrate by a known weight of magnesium."

The clean and dry funnel (without the rubber tubing and glass rod) has its bulb *B* lightly stuffed with *dry* glass wool, and is then carefully weighed. It is then supported on a ring of a retort stand and the stopper *DE* placed upon the stem. A strong solu-

tion of silver nitrate is placed in *A* and then a weighed piece of magnesium (about 0.01 g.). This is stirred about with a glass rod so as to remove the silver from the ribbon as fast as it is deposited. When all the magnesium has disappeared, the stopper is removed. As the solution runs out, the precipitated silver is retained by the glass wool in *B*. After well washing the metal, the funnel is placed in a drying oven or on a sand bath to dry. On weighing the funnel with the silver, the weight of the precipitated metal is found and its equivalent calculated. For example:

Weight of magnesium used ..... = 0.104 g.
Weight of funnel alone ..... =17.215 g.
Weight of funnel + silver ..... =18.156 g.
Weight of silver ..... = 0.941 g.

Accordingly, 0.104 g. of magnesium has displaced 0.941 g. of silver, and since the equivalent of magnesium is 12, that of silver is $0.941 \times 12 \div 0.104 = 108.1$.

In a similar manner the equivalents of other metals can be determined, it being necessary in some cases to use *hot* solutions in *A* and in the case of an easily oxidized metal (*e. g.*, copper) it is as well to aid the drying by washing it with a little alcohol and ether.

Numerous other experiments can be performed by means of this simple piece of apparatus, which under ordinary circumstances could not be undertaken by *beginners*, owing to the great manipulative skill required, but the results of which are of great educational value when "discovered" by the pupil. Thus, one can set a class of 30 pupils to work to find out the equivalent of chlorine by dissolving a known weight of silver in nitric acid, and precipitating the metallic chloride in the funnel, and on comparing the results it will be found that the equivalent obtained by *each* pupil is the same within less than one per cent of error.

A SIMPLE AUXANOMETER.

BY L. MURBACH.

Department of Biology, Central High School, Detroit Mich.

Many simple auxanometers have been devised for recording the growth of a plant at all hours of the day.* Perhaps it will be sufficient to state that simplification of apparatus, so as to

*Ganong's Plant Physiology, 1901, p. 105, refers to a number of these, and choice may be had among them.

make physiological work possible in more secondary schools, is the chief reason for giving this description of a boy's-made auxanometer. So far as I know, none of those described can be made by boys or an inexperienced teacher.

The boys were given a rough sketch, the materials, and a description of what was wanted. After the apparatus was completed and in use, a first-year student in the Drawing Department made the working drawing here presented. Of course, the wood-work was somewhat rougher than sketched, but this was no serious drawback.

The materials necessary for the device are some pieces of ¾-inch boards (ours were from a soap box), nails, a cheap nickel day clock, an empty one-pound baking powder can. First, the button on the back of the clock, for turning the hands, was soldered to the middle of the cover of the can. Then a tack or small nail was soldered to the middle of the bottom of the can. This formed the cylinder upon which the blackened paper is carried.

The boards would better be cut or split about as wide as the diameter of the clock. Two pieces are cut fourteen inches long for the top and base. The base may be doubled or nailed to a heavier baseboard for stability. In the former case it will appear 1½ inches thick as in the sketch. Next two end pieces were cut 9 inches long—enough to make an oblong frame, with the top and base board so that the cylinder on the back of the clock may stand in one end of the frame. When the frame was nailed together this end of it was left open at one joint so as to raise the top for putting the clock (on its face) and cylinder in place (see sectional view). Just where the nail or tack in the top of the cylinder came, a hole was bored through the top-board for the insertion of the nail; this keeps the cylinder upright while the clock rotates it. A pointed marker twelve inches long and ¼ inch in diameter was cut from thinner boards and pivoted to about the middle of the end of the frame opposite the end in which the clock and cylinder stand. The hole in the marker for the pivot should be ¼ the length so that the record is magnified three times.

The marker must be put on that side of the frame that will insure the cylinder being turned away from it by the clock, other-

heat of copper; t_1, the temperature of the coil; t_2, the temperature of the calorimeter and water; and t, the resulting temperature. But if a_1, a_2, and a_3 represent the stretching of the spring of a Jolly's balance due to the coil, the water, and the calorimeter, respectively, and x the modulus of the balance, then $a_1x = m_1$, $a_2x = m_2$, $a_3x = m_3$. Substituting in the first equation:

$$a_1xs(t_1-t) = a_2x(t-t_2) + a_3x(t-t_2)$$

In solving, x disappears, and

$$s = \frac{a_2(t-t_2)}{a_1(t_1-t)-a_3(t-t_2)}$$

In determining the specific heat by this method it is necessary then to find the stretching for the coil, the calorimeter, and the water. This will require a heavier spring for the Jolly balance than is ordinarily used. It may be made of No. 18 spring brass wire, closely wound on a 3/8-inch rod, and should be about two or three feet long.

In determining the heat of fusion of ice, the same principle is used. If a_1, a_2, and a_3 represent the stretching due to the ice, the water, and the calorimeter, respectively; t_1, the original temperature of the water; t, the resulting temperature; and L the heat of fusion of ice, then $a_1xL+a_1xt = a_2x(t_1-t) + a_3xs(t_1-t)$, where x is the modulus of the balance and s the specific heat of copper previously determined. Solving,

$$L = \frac{(a_2-a_3s)\ (t_1-t)}{a_1} - t$$

The heat of vaporization may be determined in the same way as the last by substituting steam for ice.

In the last two, it is advisable to make corrections for radiation as indicated in Chute's Physical Laboratory Manual. In the first corrections for radiation are usually unnecessary.

The results obtained have been quite satisfactory, considering that we were compelled to use very ordinary thermometers. For the specific heat of copper three successive results were 0.095, 0.091 and 0.096. For the heat of fusion of ice like results were 78, 77.5 and 80.4. A part of these results was obtained by the students. For the heat of vaporization of water the only results so far obtained are 542.3, 527.8, and 543.3.

The method has little value for those schools which have

a sufficient number of balances capable of carrying as heavy a load as these experiments demand. It does afford an inexpensive method to those schools which are lacking in balances that will carry a heavy load.

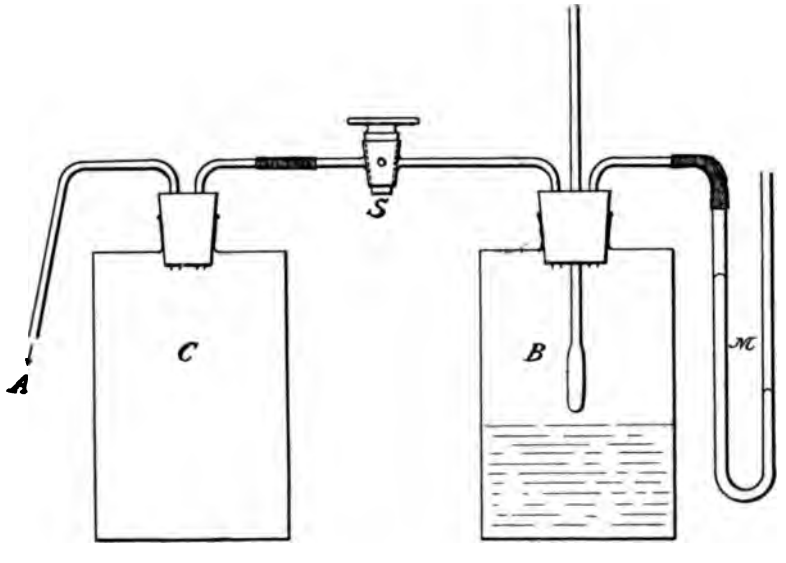
AN APPARATUS FOR DETERMINING THE RELATION BETWEEN PRESSURE AND BOILING POINT.

BY N. F. SMITH.

Professor of Physics, Olivet College.

The following simple apparatus has been found to give very satisfactory results in the hands of elementary students of physics.

A copper boiler B is provided with a stop-cock S to regulate the escape of steam, and an opening in the top into which a



rubber stopper can be tightly screwed. The rubber stopper carries a thermometer and a glass tube leading to a manometer M attached to the wall. A rubber tube leads from the stop-cock to another copper vessel C and thence to an aspirator A, which rapidly exhauts the air in B and C. The vessel C was introduced to equalize the pressure which, on account of variations in the water

pressure, was found to fluctuate slightly, and also to catch water which sometimes was forced back from the aspirator.

Under these conditions water in B can be made to boil under a pressure of from 20 to 30 cm. As soon as pressure and temperature have become constant, both are recorded. The stop-cock S is then partly closed so that steam is generated in the boiler faster than it escapes and the pressure thereby increased. By regulating the stop-cock the pressure can be kept constant at any point desired and readings of temperature made for every four or five centimeters increase in pressure. After the pressure becomes equal to that of the atmosphere the tube is disconnected from the aspirator and the pressure carried up as high as the strength of the boiler and the graduations on the thermometer will safely allow.

A range of pressure from about 26 cm. to 115 cm., corresponding to a range of temperature from about 70° to 110° was easily and safely attainable by the student and the data when platted gave a very good curve, bringing out the relationship between the vaporization and temperature of a liquid in an excellent manner.

A SKELETON TELESCOPE.

BY E. C. WOODRUFF.

Instructor of Physics, LaGrange (Ill.) High School.

"Is that all there is to a telescope?" This question was asked by a pupil of average brightness when he first saw the apparatus here to be described. The work in class on the text in light had evidently only increased the mystery of the telescope to him. The question constitutes half the argument for the writing of this article. The importance of the experiments on images in telescopes and microscopes (No. 131 in Nichol, Smith and Turton's "Manual" and No. 82 in Ayres' "Manual") is emphasized by the same argument. The apparatus is intended to furnish a definite instrument for these experiments so as to avoid the use of pick-up pieces from the outfits of other experiments. It is also intended to be used in mirror and scale work (vid. SCHOOL SCIENCE, Vol. II., p. 94,

April, 1902), where conventional reading telescopes are beyond the reach of the school. The design was originally in response to a definite request for such a device.

The construction is as follows (Fig. 1): *O* is an ordinary plano-convex lens of about 20 cm. focal length. *E* is such a double-convex lens as jewelers use—mounted, perhaps, in a flaring rubber tube *T*, and of about 6 cm. focal length. Used as a telescope the combination will have a magnifying power of about 3 diameters. *B* is a base board, 28x5x2 cm. *L* is an upright, 5x5x2 cm., screwed to *B* and carrying the eye-piece *E*. *S* is a similar upright carrying the object-lens *O*, but fastened to the side-bars *b*, one on either side of *B*, and so free to slide along the base. *C* is a cross-bar resting on top of *B* and holding the two bars *b* together. *W* is a wire, one end fastened to *B*, pointed at the other end, and bent at right angles

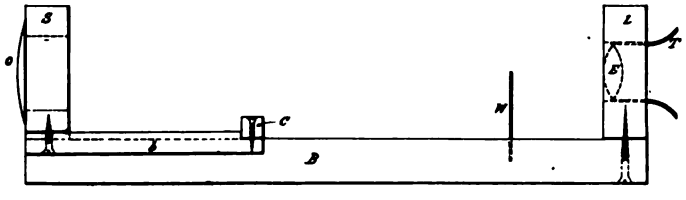


Fig. 1.

so as to bring the point horizontally into the center of the field of *E* to serve as a cross-wire.

Turn the instrument end for end and you have a compound microscope. The experiments are performed just exactly as directed in the Manuals.

Of course, when used as a reading telescope the definition is very good only in the center of the field, but that is all that is necessary. A dark cloth thrown over the instrument makes reading a little easier.

The simplicity of the arrangement appeals to the pupil. Many pupils will no doubt construct such instruments for themselves from reading glasses and hand magnifiers found lying around in most every house, thereby deriving considerable benefit.

EXAMINATION OF BAKING POWDERS.

BY WARREN RUFUS SMITH.

Department of Chemistry, Lewis Institute, Chicago.

Nothing interests the student in chemistry more than an opportunity to apply the knowledge gained in the laboratory to something with which he is already familiar. Unfortunately most of the commonest substances are of such complex constitution and composition that the elementary student can do little with them. I have found, however, that ordinary baking powders offer a field which is not beyond the skill and comprehension of the beginner. Below are some directions which students have used with satisfactory results. Of course these processes are not new and doubtless they can be improved. I offer them here simply to suggest to other teachers the possibility of similar experiments.

QUALITATIVE EXAMINATION OF BAKING POWDERS.

$NaHCO_3$	$KHC_4H_4O_6$	$KHSO_4$
$CaHPO_4$	$CaSO_4$	$KAl(SO_4)_2$
Starch	(NH_4) compounds	

1. STARCH. Treat a small amount of baking powder with cold water. Filter. Wash the undissolved residue, and boil it with water. Allow the resulting solution to cool and add a few drops of a solution of iodine in potassium iodide solution.

Blue or black color indicates starch.

2. TARTRATES. Treat with a small quantity of cold water. Filter, wash the residue with cold water. Evaporate filtrate and washings to dryness. Heat a small portion of the dry material. If tartrates are present, it will char and give the odor of burnt sugar. Moisten a small amount of the dry material with conc. sulphuric acid and heat.

Blackening indicates tartrates.

3. SULPHATES. Boil a small quantity of the powder with conc. hydrochloric acid till all dissolves. Dilute and add barium chloride solution.

White precipitate indicates sulphates.

4. PHOSPHATES. Dissolve a small quantity of the powder in conc. nitric acid, dilute with two volumes of water. Put ¼ inch of ammonium molybdate solution in a test tube and add a few drops of the nitric acid solution. Warm and allow to stand.

A yellow precipitate indicates phosphates.

5. CALCIUM. Treat with dilute hydrochloric acid. Filter, add ammonium hydroxide in excess (testing with litmus), then add a very slight excess of acetic acid (litmus), boil, filter if necessary and add ammonium oxalate.

White precipitate indicates calcium.

6. ALUMINUM AND AMMONIUM. Boil with sodium hydrate solution in a porcelain dish. If ammonium salts are present ammonia will be given off and can be recognized by its odor and effect on litmus. Filter the solution and acidify the filtrate with hydrochloric acid and then add ammonium hydroxide till alkaline.

White floating precipitate indicates aluminum.

DETERMINATION OF THE AVAILABLE CARBON DIOXIDE IN BAKING POWDER.

Arrange apparatus as in Fig. 1. *A* is a separatory funnel, *C* a dry 500 cc. flask, *D* a dry 2-liter acid bottle, *E* a liter flask filled with water, *F* a beaker, *G* a dry liter flask, and *H* a rubber tube. The rubber stoppers should be well greased. Weigh about 5 grams of powder in a test tube. Turn the powder into the flask *C* and weigh the tube again to get the weight of powder used. See that the tube *H* is entirely filled with water. Open the stopcock *B* and hold *F* so that the level of water in *F* and *E* is the same. Without altering the position of *F* close the stopcock *B* and pinch the rubber tube *H* tightly with the fingers. Remove *F* and replace it with the empty weighed liter flask *G*. Place *H* in the flask and release the pressure on *H*. Measure 100 cc. of water and put it in the separatory funnel *A*. Allow this water to run into *C*, closing the stopcock *B* just as the last of the water goes through and before any air enters the tube of *A*. Heat the flask *C* gently until its contents boil slowly for a few moments. If the contents of the flask foam, take away the burner before

the foam reaches half way up the flask. Allow to cool a little and then heat again. Do not let any foam reach the tube *I*. It has usually been boiled enough as soon as the tube *I* is hot from the steam in it. Allow the whole to cool to the temperature of the room, hastening the cooling, if convenient, by cooling *C* by setting a dish of cold water under it in place of the wire gauze. After *C* has apparently reached the temperature of the room allow the whole apparatus to stand for at least ten minues without further heating or cooling. Observe the temperature and the height of the barometer. Hold *G* so that the water in it is at

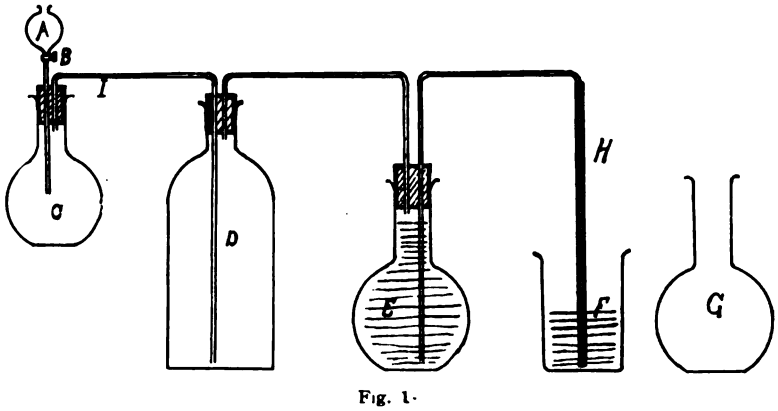


Fig. 1.

the same level with that in *E*. Pinch *H* tightly with the fingers and take away the flask *G* and weigh the water in it. This volume (minus the 100 cc. of water added) equals the volume of CO_2. Reduce this volume to standard conditions.

Determine the weight of CO_2 obtained. One liter of CO_2 under standard conditions weighs 1.977 g. Calculate the percentage of available CO_2 in the baking powder.

The greatest chances for errors lie in not having the apparatus tight and in not allowing to cool to the temperature of the room.

A COMBINED FILTER-FUNNEL AND BEAKER.

BY GEORGE GEORGE.

Headmaster of the Sutherland Technical Institute, Longton, Staffs., England.

In Fig. 1 is shown a piece of apparatus which the writer has found very serviceable in large classes in elementary chemistry, especially in experiments where precipitation, filtration and weighing are combined, as, for example, where a comparison is made of the weights of different metals replaced from their salts by a certain weight of another metal. As can be seen from the sketch, it is really a large thistle-funnel, *A*, having a bulb *B* and a short stem *C*, which can be closed by means of a piece of

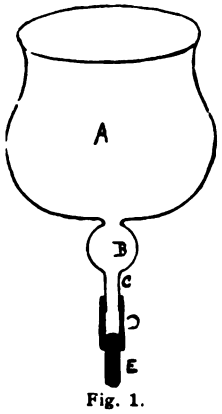


Fig. 1.

rubber tubing *D* and glass rod *E*. The diameter of the large bulb *A* is from 6 to 8 cm., its capacity about 100 cc., and its weight less than 20 g. These can be made by anyone rather skilled in glass blowing.

Use of the Funnel.—Suppose the experimental problem to be: "To determine the equivalent of silver by finding the weight of the metal displaced from a solution of silver nitrate by a known weight of magnesium."

The clean and dry funnel (without the rubber tubing and glass rod) has its bulb *B* lightly stuffed with *dry* glass wool, and is then carefully weighed. It is then supported on a ring of a retort stand and the stopper *DE* placed upon the stem. A strong solu-

tion of silver nitrate is placed in *A* and then a weighed piece of magnesium (about 0.01 g.). This is stirred about with a glass rod so as to remove the silver from the ribbon as fast as it is deposited. When all the magnesium has disappeared, the stopper is removed. As the solution runs out, the precipitated silver is retained by the glass wool in *B*. After well washing the metal, the funnel is placed in a drying oven or on a sand bath to dry. On weighing the funnel with the silver, the weight of the precipitated metal is found and its equivalent calculated. For example:

Weight of magnesium used ..... = 0.104 g.
Weight of funnel alone ..... =17.215 g.
Weight of funnel + silver ..... =18.156 g.
Weight of silver ..... = 0.941 g.

Accordingly, 0.104 g. of magnesium has displaced 0.941 g. of silver, and since the equivalent of magnesium is 12, that of silver is $0.941 \times 12 \div 0.104 = 108.1$.

In a similar manner the equivalents of other metals can be determined, it being necessary in some cases to use *hot* solutions in *A* and in the case of an easily oxidized metal (*e. g.*, copper) it is as well to aid the drying by washing it with a little alcohol and ether.

Numerous other experiments can be performed by means of this simple piece of apparatus, which under ordinary circumstances could not be undertaken by *beginners*, owing to the great manipulative skill required, but the results of which are of great educational value when "discovered" by the pupil. Thus, one can set a class of 30 pupils to work to find out the equivalent of chlorine by dissolving a known weight of silver in nitric acid, and precipitating the metallic chloride in the funnel, and on comparing the results it will be found that the equivalent obtained by *each* pupil is the same within less than one per cent of error.

A SIMPLE AUXANOMETER.

BY L. MURBACH.

Department of Biology, Central High School, Detroit Mich.

Many simple auxanometers have been devised for recording the growth of a plant at all hours of the day.* Perhaps it will be sufficient to state that simplification of apparatus, so as to

*Ganong's Plant Physiology, 1901, p. 105, refers to a number of these, and choice may be had among them.

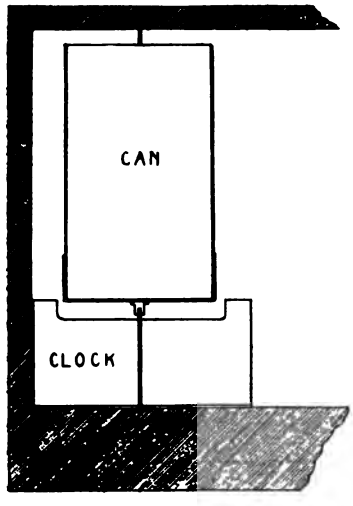
make physiological work possible in more secondary schools, is the chief reason for giving this description of a boy's-made auxanometer. So far as I know, none of those described can be made by boys or an inexperienced teacher.

The boys were given a rough sketch, the materials, and a description of what was wanted. After the apparatus was completed and in use, a first-year student in the Drawing Department made the working drawing here presented. Of course, the wood-work was somewhat rougher than sketched, but this was no serious drawback.

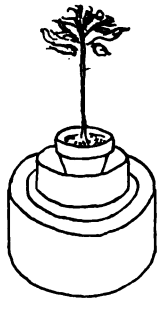
The materials necessary for the device are some pieces of ¾-inch boards (ours were from a soap box), nails, a cheap nickel day clock, an empty one-pound baking powder can. First, the button on the back of the clock, for turning the hands, was soldered to the middle of the cover of the can. Then a tack or small nail was soldered to the middle of the bottom of the can. This formed the cylinder upon which the blackened paper is carried.

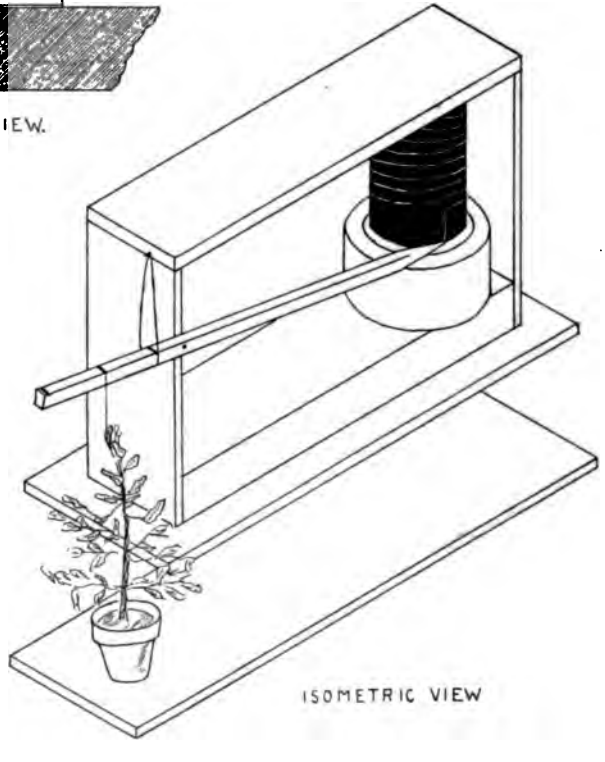
The boards would better be cut or split about as wide as the diameter of the clock. Two pieces are cut fourteen inches long for the top and base. The base may be doubled or nailed to a heavier baseboard for stability. In the former case it will appear 1½ inches thick as in the sketch. Next two end pieces were cut 9 inches long—enough to make an oblong frame, with the top and base board so that the cylinder on the back of the clock may stand in one end of the frame. When the frame was nailed together this end of it was left open at one joint so as to raise the top for putting the clock (on its face) and cylinder in place (see sectional view). Just where the nail or tack in the top of the cylinder came, a hole was bored through the top-board for the insertion of the nail; this keeps the cylinder upright while the clock rotates it. A pointed marker twelve inches long and ¼ inch in diameter was cut from thinner boards and pivoted to about the middle of the end of the frame opposite the end in which the clock and cylinder stand. The hole in the marker for the pivot should be ¼ the length so that the record is magnified three times.

The marker must be put on that side of the frame that will insure the cylinder being turned away from it by the clock, other-



SECTIONAL VIEW.





ISOMETRIC VIEW

wise the point of the marker will catch on the blackened paper of the cylinder and stop the record. With several notches cut on the end of the marker it is adapted for plants differing in their rate of growth. The elastic band outside the pivot of the marker is to take up the slack caused by the growth of the plant and thus to move the marker down the cylinder as fast as the plant grows. (See figure.)

When the clock is wound and in place some paper is pasted on the tin cylinder. This may be easily smoked from the flame of a piece of candle wicking that has been dipped in coal oil; if one application is not enough a second dip will insure a more uniform coat. A twirling motion of the cylinder, while holding the end pivots between thumb and fingers, will bring about the best result in the least time. After the cylinder is carefully placed in position the time of starting should be marked by a short vertical line and the plant immediately attached. Where it is possible the temperature should also be noted as often as possible and recorded on the line just outside the point of the marker.

When the record is complete it may be fixed while on the cylinder with shellac fixative and may then be preserved for future reference. Any writing to be done on the record must, of course, be done before the fixing.

The clock with the cover of the baking-powder can may be also used as a sort of clinostat as shown in the upper figure. A small pot of seedling morning glories, placed in the cover and one placed by the side for control will show the phenomenon of heliotropism nicely. Then if some germinating peas are pinned to a cork or to a piece of circular, soft-wood board, and some wet sphagnum or sawdust placed over them and the whole fitted into the tin cover, the effect of rotating the seedlings in a vertical direction may be observed. A few experiments may be necessary to find seeds or temperature such that the root's rate of growth and the rate of movement of the clock are about the same. Very satisfactory results have been obtained in this way without changing the rate of the clock. A very simple, though not as satisfactory way, is to remove the glass in the front of the clock and tie a small vial filled loosely with soaked morning glory seeds and sawdust, to the minute hand, lengthwise, but as near the pivot as possible.

Metrology.

TEACHING OF THE METRIC SYSTEM*

BY WM. F. WHITE

Mathematics, State Normal School, New Paltz, N. Y.

IN GRAMMAR SCHOOL AND HIGH SCHOOL

First let us consider the pedagogical problem that presents itself to the teacher of the high-school class or advanced grade in the grammar school taking up the metric system for the first time.

There should not be any need for the remark that it is absolutely necessary for the teacher of the metric system (or anything else) to understand it himself first. A man who can not estimate his own weight in kilograms with some approach to accuracy, who does not know whether a sheet of letter paper is twenty millimeters wide or twenty centimeters or twenty kilometers, who is dazed by the question how many liters a given bucket will hold, is not prepared to teach the metric system with success, even if he can recite all the tables without looking on! The need for this caution is the less excusable from the fact that the theory of the metric system can be mastered by any intelligent person of adult age by an hour or so of attentive study, and he may familiarize himself with the metric units by actually using them for a short time. Estimate in terms of metric units, and then weigh or measure. Get a metric folding pocket rule, carry it, and use it. You will soon find it so handy that you will prefer it. For small weights remember that a new 5-cent nickel weighs 5 grams.

The metric system is essentially a *decimal* system, and it must be ascertained at the outset whether the class has a working knowledge of decimals. No doubt every pupil has "passed out of decimals"; but how much did he take along with him when he passed out? A test recently made with eighty men and women not em-

*This article is not written for science teachers who, constantly use the metric system and need no advice as to the teaching of it, but for teachers of the metric system in arithmetic classes.

ployed as teachers or accountants showed that only thirty-six could perform a very simple operation in decimal fractions. Even of this number sixteen preferred to use "common fractions," although in the particular example chosen that method involved more work. Forty-four persons, or 55 per cent of the whole, were helpless in the presence of decimal fractions of the simplest sort. But of the eighty asked, all but four were able to work the example by "common fractions." Some significant remarks were reported from this test. Two who used "common fractions," said: "They are easier than decimals. More attention was given to them in school." Another did not seem to know what was meant by decimal fractions. One man who could not use decimals declared he had "a book that tells you all about it!" Another could do it if it were given in dollars and cents. The number of persons involved in this test is too small to warrant any general conclusions; and every schoolman trusts that the boys and girls today are receiving a very much better training in decimals. Still it will hardly be questioned that decimal fractions are generally not taught or understood as well as "common fractions." What is popularly known of decimals in the United States has been learned largely through the use of our decimal coinage. Europe learned decimals by using decimal weights and measures as well as coins; and the school boys of this country can learn in the same way. That is, by learning and using the metric system they can get a working knowledge of decimals. But the teacher should know early whether decimals are to be learned through the metric system or whether such knowledge is already on hand at the beginning as an asset.

But given a teacher that can use the metric system and a class that can use decimals.

Although the metric system is perhaps easier to learn than anything else that may be called a system, it presents to the beginner two difficulties, both of which, however, can be quickly removed. To secure this result, is the task to which the teacher addresses himself at the start. The two difficulties are, (1) the pupil's *belief* that the learning of the metric system is hard, and not worth while, and (2) the strangeness of the *names* used. Let pupils understand from the first that the metric system was invented in the interest of simplicity, and is as much simpler than

the English, or "customary," system of weights and measures as our decimal money system is easier to learn and use than the English system with its pounds, shillings, and pence, and for the same reason, because it is *decimal*. Let them know also that its simplicity and practical utility have been recognized by people everywhere until now the metric system is the system in common use in most civilized countries and is almost universally used in science. The strangeness of the terms employed would soon wear away, but may better be removed at once by calling attention to the same prefixes with the same meaning in other and familiar words: *Dec*ade, *deca*log, *hecto*graph, *dec*imal, *cent*ennial, *cent*, *mill*, etc. Also *mete*, gas *meter*, water *meter*, etc. The terms that are used the pupil must have on the end of his tongue; and when spoken by another, they must instantly call up the idea. *Kilo* must mean thousand as much as the word *thousand* or the number 1000.

The writer would favor the spelling *hekto-*, *deka-*, *meter*, *liter*, *gram* (instead of *hecto-*, *deca-*, *metre*, *litre*, *gramme*, the last three of which seem especially objectionable.)

The metric abbreviations adopted by the International Bureau of Weights and Measures are also the abbreviations used by the United States Bureau of Standards and by the government printing office. There can be no question as to the advisability of the teacher using these in preference to the various abbreviations found in some text books. The list of approved abbreviations and any other information on the metric system that is desired may be had for the asking from the Bureau of Standards, Washington, D. C., the recognized and official authority on metrology in this country.

It is often best, especially with children, not to introduce all the metric terms at first. And in the problems, and the class work generally, let those units be most used which are oftenest used in science and commerce.

MUST BE TAUGHT FROM WEIGHTS AND MEASURES THEMSELVES

The one mistake oftenest made in the teaching of the metric system, and by far the most serious mistake, is in teaching the metric units through their English equivalents instead of from the metric weights and measures themselves. So long as a boy,

or a man, thinks of a meter as 39.37 inches, so long the metric system will remain a foreign language to him. For the teacher to so present it, is to court failure. Let the meter stick be in the hands of the pupils, and have them measure with it. Later the liter can and the 10-gram weight, the 100-gram weight, the kilo weight, etc. Teach the metric system as if it were the only system of weights and measures in existence. In this way the metric terms soon come to have a distinct and vivid meaning in the pupil's mind—vivid because derived from experience.

ENGLISH EQUIVALENTS

After the metric system has been well learned by itself, is the time to institute comparison with the customary system, deriving equivalents, and converting weights and measures from one table to the other. Then the comparison is an excellent review of both the metric system and the English. High-school pupils should be able to use exact equivalents when desirable; but all students derive most benefit from having many problems in conversion to be solved by the use of equivalents that are easy approximations, often allowing of mental reduction. It is better that the student know and use a few such approximate equivalents as the following than that he attempt only the use of the exact values and remember none.

1 inch	and 25 mm	1 meter	and 40 inches (exactly, 39.37)
1 foot	" 30 cm		
1 yard	" 0 9 m	1 kilometer	" 0 6 mile
1 mile	" 1600 m	1 liter	" 1.05 qt.
1 quart (U S. liquid)	and 0 9 liter	1 hl	" 2 ⅝ bu.
1 peck	and 9 liters	1 gram	" 15 grains
1 lb. (avoir.)	0 45 kg	1 kg	" 2.2 lb. (avoir.)
1 ton (U. S. 2 000 lb.)	and 0.9 metric ton	1 metric ton	" 2,2 0 lb.

APPARATUS FOR TEACHING THE METRIC SYSTEM.

Full sets of apparatus especially designed for teaching the metric system are kept for sale by only one house—so far as the writer has ever been able to learn—the Library Bureau, main office 530 Atlantic avenue, Boston. These sets are attractive and very helpful. But many schools will desire to avoid the expense of purchasing a set; and the expense is not necessary. But it *is absolutely necessary that metric weights and measures be in hand and used.* These can be made by the pupils themselves. If possible a good metric chart (such as one of the American Metrolog-

ical Society's or the Library Bureau's) should be procured and kept hanging on the class room wall throughout the year. Beyond this, there need be almost no expense.

Rules—3 dm on one edge, 12 inches on the other—retail for one cent. A meter stick may be made by marking the graduations on a light moulding or a well-planed scantling. A good maple stick is preferable. It is well to cut the lines in with a sharp knife and then run over them with pen and ink. This secures clear, sharply defined, permanent lines. A neat little rule—say 10 cm long—may be cut from cardboard.

A cubic centimeter cut out of wood or other material may be required of each pupil, to give him a definite idea of this important unit.

A cardboard liter box, cubical, each of the three edges that converge in one corner graduated to cm, and one of the faces divided by lines into 100 cm^2, pictures to the eye 1 dm^3, made up of 1000 cm^3, and shows the relations between the tables of length, surface, volume and capacity.

It is often an economic arrangement to let the boys produce the meter stick and the wooden cm^3, and the girls the cardboard rule and liter box. The girls have made paper boxes in their play and need but little instruction about the making.

To hold water—necessary in gaining acquaintance with the capacity measures and especially in showing the relation to the table of weights—tin capacity measures are needed. Cans may be labeled with size, date, and student's name. It is desirable to have measures illustrating the liter and several of the commoner fractional parts of it. Some three-pound tomato cans are fair approximations to one liter. A 1½ pound corn can is close to the half liter. A condensed milk can was found to approximate the quarter-liter; and a quarter pound deviled ham can, the deciliter.

A good balance is too difficult for children to make. If the school does not possess a scale, one can usually be borrowed; but a spring scale or steelyard, or any form of scale depending on an arc or arm graduated to the English system, is manifestly not desirable.

For small weights, the most convenient material is lead in

the form of printers' space lines. Use the thick leads, called "slugs." They can be cut with old shears, and the name of the weight can be scratched into the lead. For larger weights, perhaps the handiest device is to load small baking powder cans with pebbles or shot.

Among the weights needed is one equal to the weight of the empty liter can that is used to show the relation, 1 liter of water weighs 1 kg. (Though, in strict accuracy, the liter is defined as the volume of a kilogram of water weighed under standard conditions, and in the nature of things can be only a very close approximation to the cubic decimeter, the teacher would best neglect that distinction, and present as above, which is also the historic method of approach.)

Not all of the apparatus need be made by the pupils of any one class. They take pride in their work if it is known that, of all that are made by any one class, the best specimens are to be retained as part of the school's permanent equipment.

Class-made apparatus is not accurate. But it is sufficiently so for the purpose; there is often a choice between that and none; and the making of the apparatus is no small part of the training.

UTILITY OF SYSTEM SHOWN TO PUPILS.

Students can not be expected to long retain interest in anything whose utility they do not see, or in which they do not soon acquire some degree of proficiency. For this reason, the first table that is taught should be used and made an effective instrument before the second is presented. Students should see clearly that metric reduction is only moving the decimal point. *E. g.*

m	dm	cm	
2	5	8	= 2.58 m = 25.8 dm = 258 cm = 2580 mm
m		cm	
4		9	= 4.09 m = 40.9 dm = 409 cm = 4090 mm

When, after a few minutes practice, such reductions can be made mentally, instantly and correctly, let some of the class take an example in reduction in the English linear table (such as yards to inches, or inches to yards) and others of the class take one in the metric table (as above), and let them compete, both as to speed and accuracy. When they have changed about and all have become convinced that the metric system is a time-saver—is the school boy's friend—then the teacher's work is

half done. Such an exercise should be reached before the close of the second recitation period.

REVIEWS

Such a course as that suggested above might take two weeks of the class's time usually given to arithmetic. The students should then be able to use the metric system much better than they can ever use the English system. But, like any other subject, the metric system must be reviewed to be kept. Better than to learn it, drop it, and later review it, is to have it kept in the mind by frequent use, later problems in arithmetic and the work in science making it part of the pupil's permanent mental outfit.

METRIC SYSTEM IN THE PRIMARY DEPARTMENT

The foregoing suggestions are to grammar-school and high-school teachers of arithmetic. But when the metric system becomes the only American system of weights and measures, it will of course displace the foot rule, the quart can, and the pound weight in the primary school. The children will use *meter* and *centimeter, liter* and *centiliter, gram* and *kilo.* These will be sufficient for them. The other metric terms can be added later one by one as needed. The system will be very concrete, will be kept in use in every grade and every day, and, displacing the hard tables of the present customary "system," will save much time in the pupil's school life for useful pursuits.

IN BRIEF

1. Remove impression that metric system is difficult, and create interest in it.

2. Teach it independently of the English system. Then review both by problems in conversion.

3. Use caution in introducing metric terms—not too many at a time. Avoid needless complication of the nomenclature.

4. Place the emphasis on those denominations and those applications of the system which are oftenest met in science and commerce.

5. Make clear the advantage of a decimal system, both theoretically and by early and frequent practical application and comparison.

6. *Have the weights and measures in hand, and see that they are used. Teach pupils to think in metric terms.*

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

BIOLOGY.

In the report of the Pittsburg meeting of the Botany Club of the A. A. A. S., there are several titles that interest teachers of biology. They are: "Notes on Material for Class Demonstration," by Mel T. Cook, and a cheap and convenient laboratory aquarium, museum methods and demonstration of life-histories by Dr. F. E. Lloyd.

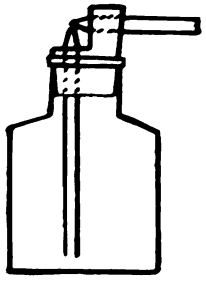
The strength of ants is strikingly shown by Armand Miller in a three paragraph note in *Science*, Sept. 26, where he tells about his surprise on weighing an ant and the burden she was dragging—a grasshopper. The ant weighed 3.2 mg. and the grasshopper 100 mg. Would it not be a remarkable man who could drag a 4½ ton load?

That the water or land form of the leaves of Proserpinaca palustris is due to the amount of water in the protoplasm, is shown by McCallum in an interesting preliminary paper in the August number of the Bot. Gazette. Transpiration is checked in the water and facilitated in the air. After excluding the factors CO_2, O, light, nutrition, temperature, salts, etc., the contact stimulus was eliminated by finding that the water form of leaf was developed in moist atmosphere. The author then clinches his conclusion by growing the land form of leaf in a culture which withdraws some water from the protoplasm of the plant.

School instruction in the effect of stimulants and narcotics as given in a "preliminary report" in *Educational Review*, June, is of interest to physiology teachers. It is made by a committee of the New York State Science Teachers' association. Standard and school texts are compared in parallel quotations; questions sent out to teachers in the state and the answers received are given. Nine conclusions are drawn, the most important being, that "the evils of alcohol and narcotics can be presented most effectively from the moral and economic point of view." The report closes with four recommendations, two of which might serve

the readers as precisely what to teach. In a later number the Educational Review refers to a long reply to this report issued by the New York State Central Committee for scientific temperance instruction which the editor recommends procuring and reading, though he does not at all indorse it.

A Simple Atomizer.—When the laboratory atomizer cannot be found for fixing a drawing or chart, a very simple atomizer may be easily constructed. Find two glass tubes, one an inch taller than the bottle containing the shellac, the other any convenient length to blow through. Draw each to a point in the flame, leaving a little larger opening in the blowing tube than in the upright one. Put the shorter tube into the bottle, then blowing a stream of air over the point of this tube will produce the desired spray. To give greater stability the tubes may be held at right angles to each other through perforations in a cork, a quadrant of which has been removed where the tubes are to meet. A rubber bulb may serve as a blower.



"For successful investigation," says Professor O. F. Cook, of Washington, in *Science*, Oct. 3, "the first and most essential preliminary is an interest in the question. The investigator, like the author, must first be born. His training determines the degree of excellence. No amount of training can remove organic defects, but bad training may be worse than none in lessening the attainments of the most capable. The investigator must not only be born, he must be allowed to grow up." * * * "It is not strange that after youth consumed in our modern and efficient system of kindergarten, primary, grammar and high school, college and university, the graduate and even the post graduate continues to expect somebody to tell him what to do next."

L. M.

CHEMISTRY.

Carbon Bisulphide is now manufactured on a large scale by electrochemical means, being produced by direct union between the vapors of sulphur and carbon in an electrical furnace.

Silicides of the Alkaline Earth Metals, $CaSi_2$, $BaSi_2$ and $SrSi_2$, analogous to the carbides, CaC_2, etc., are now being manufactured by heating in an electric furnace, to a temperature higher than that needed for carbides, a mixture of the carbonate, oxide, sulphate or phosphate of the metal concerned with silica and enough carbon to effect the reduction. These silicides are crystalline and of a bluish-white color. They react with water to give hydrogen, one pound of calcium silicide yielding, in a

common acetylene generator, 18.5 cubic feet of pure hydrogen. These qualities suggest a field for generating hydrogen in the laboratory or for ballooning purposes. Barium silicide has the property, if put into molten iron or steel, of combining with the sulphur and phosphorus therein, removing them in the slag as barium sulphide or phosphide. They are also good reducing agents, working in either acid or neutral solutions.

The Uses of Barium Hydrate, now that it can from improvements in its manufacture by electrochemical processes be placed on the market at as low a price as 3 cents per pound, are increasing with astonishing rapidity. It is used "in the paint trade, for making white paints; in the sugar trade, for recovering sugar (as insoluble barium saccharate) from waste dilute solutions, and for softening boiler waters. The mother liquors from the crystallization of hydrate, containing barium sulphide and sulphydrate, have been found useful in removing hair from hides, a solution diluted to 2½ per cent, removing all the hair from a hide in 3½ hours' immers[illegible] without any injury to the leather. The same solution is very [illegible]e for preparing the white paint called "lithophone," which is made by running a solution of zinc sulphate into barium sulphide solution, thus producing the precipitated pigment, a mixture of barium sulphate and zinc sulphide. The mother liquors can also be converted into barium carbonate, which has found application in the cyanide industry and also in the manufacture of bricks; for mixed in small proportion with the clay, it is said to prevent red bricks from turning white and white bricks from turning green."

Electrochemical Industry, I. p. 18.

Water of Crystallization.—In testing salts as to whether they contain water of crystallization or not, it is a common procedure to heat them in test-tubes. Even when great pains are taken to keep the mouth of the test tube lower than its closed end so as to prevent the expelled water from running back on the hot glass and thereby breaking the tube, the mortality rate of the tubes is not inconsiderable. By the following modification of the experiment a greater degree of success is attained. A little frame of iron wire is made and placed upon a wire gauze (best of copper, as a flame strikes through an iron one too easily) supported on a ring stand. This frame is of such a shape that it supports the closed end of a 4-in. test tube about a centimeter above the gauze while its open end projects a little beyond the gauze. A flame is placed under the gauze and so regulated that it heats red-hot a spot of it 2 to 3 cm. in diameter. The salt placed in the tube is thus uniformly and moderately heated and gives off its crystal water with no danger of its running back and breaking the glass.

A frame can be arranged so that three or four test tubes can be placed at once on the gauze, their closed ends converging to a common center beneath which the flame is placed. In this way several salts can be under observation at the same time, whereby not only is time saved, but also a stricter comparison of the behavior of the salts is made possible, so that it is unlikely that the student will mistake mechanically enclosed water for water of crystallization.

Book Reviews.

Essentials of Chemistry. By JOHN C. HESSLER, PH. D. and ALBERT L. SMITH, PH. D. 13x19 cm., xxi+405+96+xx pages. Benj. H. Sanborn & Co., Boston, 1902. $1.20.

This book represents a decided advance in the teaching of elementary chemistry. The authors, recognizing "the fact that the terms and ideas of Chemistry are *outside of the common experience*, and that it is useless to expect the pupil to grasp theoretical conceptions before he has become acquainted with the fundamental phenomena of the science," have arranged the sequence of topics so that the student is led gradually and logically up to a knowledge of the best sort of chemistry. They have had in mind continually the limitations of both pupil and teacher and have produced a book that is modern and scientific, yet not too difficult.

The treatment of the subjects of equilibrium, mass action, dissociation and ionization has been accorded the place it deserves. The chemical equation also has been presented, with its limitations made clear, and there is no danger that the pupil who studies this book will get the notion that chemistry is the science that treats of atoms.

The laboratory course, designed to accompany the text, is placed at the end of the book. The experiments are simple and well chosen, and the directions for their performance show that they have been repeatedly tested and worked over.

Taken all in all, the book is admirable, and its use cannot but contribute greatly to lifting the study of chemistry up on a higher plane than it now occupies.

C. E. L.

Physiology by the Laboratory Method for Secondary Schools. By WILLIAM J. BRINCKLEY, PH. D. 13x21 cm., xvi and 536 pages. Ainsworth & Company, Chicago, 1902. $1.25.

In no recent textbook of physiology has there been so clearly illus-

trated the effect of modern methods on scientific teaching as in this; even its title suggests the radical change which has taken place in the character and scope of the instruction during the last decade in this somewhat neglected branch of science. Its initial impression on the reader is in line with this, tempting one to a hasty review of the various textbooks of physiology now in use in our high schools, and the striking difference between them and this one, both in subject matter and manner of treatment. Such a review would prove advantageous to Mr. Brinckley's book as regards many of its features, and could not help suggesting upon how much firmer a foundation physiology stands today than a few years ago.

Briefly outlined, the plan of the book is as follows: An introduction which relates the human body to other bodies, followed by an analysis of the elements of the body considered microscopically. The first system introduced is the muscular, and in this section is an excellent reference table of the principal muscles. This is followed by a discussion of the nervous system. The text in connection with this is very full, and the diagrams of nerve-tracts deserve special mention.

It seems a little unusual that the subject of the skeleton is placed between a section on nerves and on digestion, but its position is a matter of secondary importance.

Digestion and kindred topics (circulation, metabolism, etc.) are very thoroughly considered, much space being given to experiments on foods.

After a discussion of the ductless glands and the special senses, the remainder of the book, constituting about fifty pages of Appendix, is given over to the discussion of histological methods, directions for the use of the microscope, poisons and their antidotes, and diseases and their prevention. This section is taken largely from the Michigan State Board of Health bulletins. Last of all is a chapter on First Aid to the Injured. The text is followed by a glossary and index.

The amount and detail of the work render it unsuitable for use in the lower grades in which physiology is frequently taught in our public schools. It may be used by judicious selection of experiments in schools where the subject is taught in the senior year, but would seem to be of more value in normal schools and colleges, to which it seems specially adapted.

It is a valuable reference book for any teacher of physiology, not only on account of the text, but also for the suggestiveness of the experiments. The illustrations are very numerous and clear, the colored plates being especially fine, which, with the tables of muscles, nerves, etc., constitute a striking feature of the book.

Whether it is possible for secondary school teachers to make use of the book or not, it deserves wide recognition among them as evidence of a decided change in the scope and aims of the teaching of physiology.

GRACE F. ELLIS.

The Science of Mechanics. By Dr. Ernst Mach. Translated by Thomas J. McCormack. Second Revised and Enlarged Edition 13x19 cm. and xx+605 pages. The Open Court Publishing Co., Chicago, 1902. $2.00.

The subject of Mechanics is usually regarded as the driest and hardest of physics. Text-book writers in their efforts to cover the whole field of physics and to present the more modern developments in a volume that is to be designed for a single year's course in our schools have condensed the subject of Mechanics so much that little more than dry dust and bones are left. The pupil struggles through this in hopes (buoyed up often by the teacher's assertions) that the other parts of physics will prove more atractive. Now this teaching of mechanics can be made vastly more profitable and interesting if its history and development be introduced. The very methods of discovery employed by the pioneers in the science are usually the best methods for presenting the subject to the learner. They may seem more clumsy and roundabout than those now prevalent, but for that very reason they are the more readily comprehended by the immature mind. A humanistic touch here and there helps wonderfully in arousing attention and sustaining interest. Now there is no excuse for not applying this historical method to some degree at least. The book under review is a masterful presentation of the subject of mechanics, much of it being not too hard for the beginner. It is "a critical and historical account of" the development of the science of Mechanics. The author puts us in direct personal contact with the discoverers of the principles of the science. He makes us appreciate their difficulties and shows us how they were surmounted. We see what this man and that contributed to the progress of the science. We learn how the science came to be what it is now. As said above, much of this matter can be told the beginner in the course of the study and its value thereby much enhanced. No teacher can afford not to carry along some course of reading in line with his work, and certainly the perusal of this book will improve the teacher and his work as much as anything can. The book cannot be too highly recommended.

C. E. L.

The Teaching of Chemistry and Physics. By Alexander Smith, B. Sc., Ph. D., Associate Professor of Chemistry in the University of Chicago, and Edwin H. Hall, Ph. D., Professor of Physics in Harvard University. 14x20 cm., 377 pages. Longmans, Green & Co., New York, 1902. $1.50.

This is a volume in the American Teachers' Series, edited by Dean James E. Russell, of the Teachers' College, Columbia University. It is composed of two distinct parts, one on Chemistry, by Dr. Smith, and the other on Physics, by Dr. Hall. According to the Editor's Note, "the authors of the separate parts have conferred frequently during the progress

of the work, and have endeavored to avoid unnecessary duplication. There are thus some subjects of equal importance to teachers of chemistry and physics which are discussed in one of the sections only. In a few instances, however, the divergence between the opinions of the authors seemed to make it desirable that each should present his own. It has been deemed better to have a logical presentation, even at the risk of disagreement, than to give the impression that there is only one way of conceiving or giving class instruction."

The authors' division of this book into two distinct parts makes it desirable to review it as if it were two books. Accordingly, the review by the undersigned will be devoted solely to the 227 pages covered by the Chemistry.

The reviewer has read this book with profit, satisfaction, and dismay. With profit, because he found much he could use; with satisfaction, because he found much he already was using; with dismay, because he found much he had never used. A second examination of many parts shows that the author has thought out to a working solution many problems seldom considered by most college teachers of general chemistry, and, of course, not comprehended by most secondary teachers, because the secondary teachers were once students of these very college professors. With all kindness, it must be said that many of the shortcomings which Dr. Smith lays upon the shoulders of high school teachers go back to the college course in chemistry, with its dogmatism, vagueness, lack of unity, incompleteness, and sterility. But the high school teacher has no longer any ground for ignorance of the pedagogic side of chemistry, for Dr. Smith has supplied the very book we have all so long awaited. There is no longer any ground for ignorance, I repeat, because this book commands attention, inspires confidence, literally sweeps away many traditional difficulties. It is a vital, human, sympathetic book, destined to outlive many a contemporary textbook.

The author utilizes many current sources of information—both American and English—but he has generously given credit in most instances. Indeed, these direct citations are a prominent feature of parts of the book, and, together with the bibliographies, they contribute largely to the permanent usefulness of the book as a whole. The references serve to elucidate the points of the author, and are not to be understood, as he himself says, "to indicate emphatic approval of those works as wholes." In some instances Dr. Smith judiciously leaves the reader "to reach a decision for himself."

The Introduction presents some reasons for the study of science, a brief history of chemical instruction, and a consideration of the present condition of chemistry teaching. Regarding the last point, he says (p. 27): "At present the average instruction in chemistry does not even remotely approach, in the benefits which it gives, the best that can be given or is given." This is doubtless true and would be depress-

ing if this very book did not contribute effectively to the attainment of a more desirable end.

As to the place of chemistry in the curriculum, the author believes (1) "physics must come first" (p. 33), (2) "probably at least twice as much can be done in the fourth year as in the first, on this account alone" [general advancement of the pupil] (p. 37), and (3) "many bodies of recognized authority incline to recommend the placing of chemistry late in the course" (p. 39).

Under the rather narrow title, "Introduction of the Subject," the author discusses some impediments to be overcome in teaching science, the character of introductory work, the three general classes of text books, generalizations of a qualitative and a quantitative nature, and the relation of quantitative laws to formulæ and equations. The last two points deserve emphasis. Dr. Smith makes it very clear that quantitative work of a simple, but judicious, nature should be a part of the early work, and that the pupil should be taught that weight is the only physical property of matter which it preserves in chemical transformations. Incidentally, he cites (p. 74) a simple experiment to illustrate multiple proportions. Pages 77 to 84 should be read and pondered over by every teacher of chemistry. They cover the interpretation of quantitative data, and are too long to quote. The main point is, "the equation can never be understood unless a quantitative measurement is brought to the notice of the pupil, its numerical result seen, and its translation into the form of an equation exhibited." And the reviewer believes that the pupil should make this measurement. The author further says (p. 83): "In view of the fact that equations, symbols, formulæ, etc., are not parts of chemistry, but our mode of recording chemical facts, it seems desirable to plant the facts and their importance securely in the mind of the pupil before these conventions are considered. Since they are quantitative expressions, they cannot logically appear before the method of measurement has been explained." We are under deep obligation to Dr. Smith for emphasizing this relation of fact and theory, and especially for the concrete illustration given on pages 78 ff., showing the logical relation between experiment and equation.

In the fourth chapter the author discusses instruction in the laboratory. Here again we have a wealth of suggestions, fresh from the keen mind of a teacher who realizes the place of laboratory work, for he says (p. 91) "the course should be arranged round the laboratory work, and the latter should carry the thread of the subject." He rightly emphasizes the importance to the teacher of a knowledge of the psychology of laboratory work, discusses fully the essential features of laboratory directions, the attitude of the pupil, and the necessity of teaching laboratory technique early in the course. This chapter also contains a helpful discussion of the value, limitations, scope and applications of quantitative work. It is one of the most helpful parts of the book. The author's

position on this subject may be judged from the following: "We have already referred to the emphasis which is necessarily laid in chemistry upon quantitative measurement and the interpretation of the results. Imaginary examples, as we have hinted (p. 80), may serve when actual ones are not available, but the ease with which properly chosen measurements can be carried out leaves little excuse for their ommission, either from demonstration or from the laboratory work of the pupil." He appends a selection (by citation) of suitable quantitative experiments (p. 117).

Instruction in the classroom is discussed in Chapter V. A strong feature of this chapter is the judicious treatment of the relation of "everyday chemistry to a well balanced course." "The object of the references to everyday life will be defeated if they give occasion for long descriptions of these matters" (p. 142), and "reference to the chemistry of matters of common knowledge is suggested simply as one means of attaining the main end of the course, by making the subject memorable, attractive, and digestible," sum up the author's views. Another commendable feature is a frank though somewhat incomplete discussion of such misleading terms as "strong acids," "stable bodies," "water of crystallization," "saturation," "allotropism." We must also thank the author for referring to Pearson's Grammar of Science and the other books cited on page 153.

Chapter VI deals with some constituents of the course in chemistry for a secondary school, special attention being given to the atomic theory, valence, physico-chemical investigations, and quantitative analysis. The part devoted to the atomic theory and valence is admirable. As to physico-chemical ideas, the author rightly says (p. 168), "we cannot now teach chemistry and avoid frequent mention of electrolytic operations; and we cannot well make these explanations intelligible without some explanation of the theory." The reviewer heartily agrees with this statement, though he believes that pupils see very little in the theory and very much in the fact. The author believes that qualitative analysis can be replaced by more sensible and serviceable "exercises in identification"— a view supported by the best authorities.

Chapter VII is devoted to a detailed treatment of the laboratory and equipment. This chapter will prove very helpful to teachers who are suddenly called upon to improve their present quarters or to move into new ones. The author rightly insists on adequate equipment.

The last chapter—like the whole book—is for "the teacher, his preparation and development." Special emphasis is laid on the teacher's need of the best possible knowledge of general chemistry. He says (p. 208), "it is a knowledge of the science as a whole and not of any special section of it which will count in elementary instruction." A comprehensive list of books is appended.

The only omission of consequence is a discussion of the place of the periodic law in secondary teaching. Possibly the omission is the only discussion this topic needs!

The book is recommended to every teacher of chemistry—in college and out—as the sanest available treatment of this subject.

L. C. N.

Perhaps no better idea of the general scope of Part II. of "The Teaching of Chemistry and Physics" can be given in brief space than is furnished by the headings of the various chapters. These are: I. Whether to be a Teacher of Physics. II. Preparation for Teaching. III. The Teacher as Student, Observer, and Writer. IV. Problems of Laboratory Practice. V. School Text-Books of Physics. VI. Discovery, Verification, or Inquiry? VII. The Technique of Laboratory Management. VIII. Lectures and Recitations. IX. Physics in Primary and Grammar Schools. X. Physics in Various Kinds of Secondary Schools. XI. On the Presentation of Dynamics. XII. Plan and Equipment of Laboratory. XIII. Physics Teaching in Other Countries.

No attempt is made to present, in these chapters, anything fundamentally new or in the nature of a radical departure from present generally accepted aims and methods of teaching physics. The book offers, rather, a plain statement, usually accompanied by ample comment and suggestions, of the status of physics teaching as now provided in the best secondary schools. Considerable space is devoted in Chapters IV to X, to the Harvard Descriptive List, to the report of the National Educational Association Committee on College Entrance Requirements in Physics, and to the report of the Committee on Methods of the Eastern Association of Physics Teachers. As it is to be assumed that progressive teachers of physics are already familiar with these reports, the value of these chapters lies in the accompanying criticisms and suggestion offered by an experienced teacher, whose opportunity for observation and judgment upon the work of the secondary schools has been in some respects unusual. In all such criticism, Dr. Hall is conservative. There are few flights of fancy in his book, and much statement of fact.

Laboratory methods, the proper arrangement of periods and best grouping of students for laboratory work, the functions and special values of lecture and recitation periods, notebook keeping, and the form and character of laboratory reports, are given quite full consideration. Concerning the proper method for laboratory work, the author has this to say:

"There is very little to choose between the method of verification at its worst and the pseudo method of discovery. The former says to the pupil, 'The fact is so and so; make observations accordingly. The latter says, Make observations; from these discover the fact, which is so and so.'

We need something better than either of these methods to justify the expense and work of laboratory courses. I would keep the pupil just enough in the dark as to the probable outcome of his experiment, just enough in the attitude of discovery, to leave him unprejudiced in his observations, and then I would insist that his inferences, so far as they profess to be derived from his own seeing, must agree with the record previously made and unalterable. * * * This knowledge is not necessarily inconsistent with the fore knowledge of what the result sought should be according to the testimony of books."

A commendable feature of the chapter on "Preparation for Teaching" is the emphasis with which the prospective physics teacher is urged to pursue engineering study. A subject which, like physics, deals with transportation, construction, and the ways and means of daily industry, comfort, and pleasure, should be taken outside the class-room into real life. The teacher, who has some acquaintance with engineering terms and processes, possesses the means for adding immensely to the interest and efficiency of his teaching. Such knowledge of engineering will be a necessity to the physics teacher of a few years hence.

Only one chapter of the book is devoted to the pedagogic treatment of any specific part of physics. In this, dynamics is selected as being at once fundamental, and yet so often neglected or poorly taught. It is to be regretted that so little should be written into this chapter of a character to really clear up this too often confused and unsatisfactory part of the subject. Surely, if dynamics is to be treated at all, one has a right to expect something more helpful than a rather discouraging and negative catalogue of the difficulties which beset this particular part of physics, of error which this or that teacher who should know better, has committed, and of formulæ, most of which may be found in any ordinarily good text book in Mechanics. The equations, $f = m\ a$ and kinetic energy $= \frac{m\ v^2}{2}$ are, of course, the usual ones of the absolute system of units. To use the equations $f = \frac{m}{g}\ a$, and kinetic energy $= \frac{m\ v^2}{2g}$ for the gravitation system is to invite confusion in the mind of the pupil. Since it is the *force* which is measured in different units, and these units are *g times as large* as in the other system, logic would seem to demand the form $\frac{f}{g} = m\ a$, just as we might write 100 dimes as $\frac{100}{10}$ dollars.

But why avoid the term weight, and the equations of the engineer? While the physicist's fundamental units are mass, time and space, the engineer finds it more convenient to adapt for his, *force*, time and space. His equations are, therefore, $f = \frac{w}{g}\ a$, and $K.E. = \frac{w\ v^2}{2g}$. The engineer's term mass is therefore a name given to the fraction $\frac{w}{g}$, which he may use in the expression *force* = *mass* × *acceleration*. Such procedure may be unscientific, but it is certainly convenient and will doubtless endure. Why not recognize this, point out the origin of the practice, and then

let our use of gravitation units conform to that of the business world? One properly expects the author to do this after the position taken earlier regarding engineering study. The book would be stronger, also, had more space been given to the subject of dynamics, even had this required a curtailment of the discussion of special laboratory procedure of less general value or use, such as the preparation of tubes for the coefficient of expansion of air experiment, or the omission of rules for the use of the double-platform balance.

One is inclined, also, to take issue with Dr. Hall regarding the suggestion that a secondary school teacher should confine himself to problems on the adaptation of simple and sometimes crude apparatus to laboratory work, as being more in keeping with his attainments, instead of giving a part of his time to wider reading and investigation, thus obtaining the stimulus which may come through time thus spent, even though no actual use may be made of such material or information in the class-room.

However, as a whole, the book must prove a valuable one for the young teacher starting on his life work—whom, if we read the prefatory note, we must believe the author had prominently in mind in writing the book—as well as suggestive to the more experienced teacher. A detailed description of a very complete laboratory of a general type, suitable for secondary school work, and a brief account of the status of physics teaching in other countries, are given in the closing chapters.

J. M. Jameson.

Reports of Meetings.

UPPER PENINSULA EDUCATIONAL ASSOCIATION.

The association held its seventh annual meeting at Marquette, Mich. October 30 to November 1, 1902. One of the most helpful features of the program was the address, Friday night, by President Angell, of the University of Michigan, on "The Reflex Influences of the Teachers' Profession." He pointed out some of the dangerous tendencies that teaching stimulates in the teacher—pedantry, egotism, etc., and the more desirable traits almost unconsciously acquired.

An occasion of much interest was the dedication of the new science building of the Northern State Normal School. This is a two-story, brown stone building, 65x105 feet, used for the science work—the first floor for chemistry and physics, the second for biology. The building has been but recently completed and occupied. In President Angell's felicitous dedicatory address, he emphasized the value of the scientific training in imparting to the student the scientific method of thinking—exact induc-

tion from known facts, rather than the loose knowledge and theorizing that marked many subjects before the scientific method was in vogue.

Hon. Delos Fall, in accepting the building for the state, spoke in commendation of the work of those early educators in the Upper Peninsula, to whose ideals and efforts we now owe so much.

No meetings of a special Science Section were held during the Association Session, except one to organize, so that next year the science teachers and others interested may meet for the discussion of their own special problems. The science teachers, however, met informally to look over the new building and its equipment, and to see a demonstration of projection work with the stereopticon and microscope.

Reported by ELLIOTT R. DOWNING.

Correspondence.

EDITOR SCHOOL SCIENCE:

Aside from suggestions made in an article on the subject in the October number of SCHOOL SCIENCE, I have noticed that amoebæ are apt to occur about fresh water sponges.

They can be readily distinguished from the amoeboid cells of the sponge by their greater activity, more transparent bodies, and much greater size. Then, too, the amoeboid cells of the sponge are often filled with ingested food particles and are more nearly spherical in form than are the free amoebæ. Picking apart a bit of sponge on a slide will usually yield a number of large active forms.

Central High School, Grand Rapids, Mich. GRACE F. ELLIS.

EDITOR SCHOOL SCIENCE:

On page 195 of the October number, Professor Norton speaks of the lack of modern methods in physiography. Most of the teachers who are responsible for the conditon are fully aware of it, but do not see their way clear to change. Even in those few schools where special training for physiography has been demanded a teacher who received his training six or eight years ago might be hopelessly old fashioned and in most smaller schools physiography goes to the one with a vacant period.

Unless the teacher can take a summer course, he is at sea. Most books, either physical geographies or geologies, give general principles enough, but the teacher needs to know *exactly* what a certain spot in the neighborhood illustrates, and everything about must be known in detail to have a field excursion at all satisfactory. If one could only secure the services of an expert for about a week and tramp about the country with him, the work would be comparatively easy. Next to such help come such articles as Mr. Goodrich's (SCHOOL SCIENCE, Vol. I., p. 249). While our time is too limited to admit of the number of excursions Mr. Goodrich took and our little creek did not show all that his stream did, I followed the plan of his work quite closely, and was pleased, though not entirely satisfied with the results. I shall look eagerly for something more along that line.

Mr. Grout, in his article in the October number on "Laboratory Material for General Biology," stopped too soon. He had not reached my chief trouble, but possibly he has not contracted the foolish habit of keeping all kinds of living specimens for his classes to study. I have a decided preference for living things and am harassed every year by the fear that they do not get enough to eat. The biologies state that they will eat this, that and the other thing, but I can't get them to do so. I should be glad to learn sometime how other people feed snakes, frogs, turtles, giant water bugs, water scavenger beetles, etc., etc. Only the water bugs and whirligig beetles will touch beefsteak, books and *books* to the contrary, notwithstanding, and my snakes will not eat even small mice. I console myself with the thought that they usually hibernate, but have serious doubts as to their real happiness.

Teacher of Biology, Morrison (Ill.) High School. HELEN A. SOUTHGATE.

School Science

VOL. II] JANUARY, 1903. [No. 7

REVISION OF PHYSICAL THEORY.*

BY PROF. HENRY S. CARHART.

Professor of Physics in the University of Michigan.

Physics, as a rational body of knowledge, is hardy and of slow growth. It has none of the characteristics of the mushroom, but rather those of the oak. It has not grown up in a night, nor even in a century. On the contrary it is the product of many centuries, and it has drawn its nourishment from many lands.

From another point of view it resembles a coral island which slowly emerges from the sea, with occasional subsidences and engulphing in the ocean. When it has finally risen from the water and has acquired soil from wind and wave, stately palms crown it and it becomes green with tropical verdure.

The essential element in physics which I wish to emphasize is *growth*. Not death and decay, but the development of living tissue, enlargement by accretion, assimilation, and cellular growth. Now growth and development mean modification, elaboration, flower and fruit, the bare limbs of winter and the grateful foliage of summer. They mean an incessant struggle upwards toward the light.

Physics is a living body of truth, a growing science; and as such it exhibits incessant change. It is sometimes profitable and suggestive to take a survey of some of these changes and to note the appearance and sway of physical theories, followed frequently

* An address delivered before the Central Association of Physics Teachers, Nov. 28, 1902.

by their disappearance, either gradually or with theatrical suddenness. A mighty magician appears, or some new and astounding fact emerges into view; theories are called upon to justify their title, and a readjustment of scientific doctrine becomes imperative. The physicist, who is more intent on ascertaining truth than preserving consistency, holds to a physical theory no longer than he finds it able to furnish support and lend aid. The laws of nature represent the survivals of the fittest theories. Disappearance denotes unfitness to survive. A theory may contain the kernel of a great truth, but overlaid and surrounded with husks and shucks. Time removes these. They may serve a useful purpose in guarding and preserving the kernel till the time arrives for it to germinate, when temperature and soil and sun are favorable. The husk then decays while the inner living principle survives.

It is not difficult to recall instances illustrating the revision which physical theories have undergone in the past. We are all familiar with the famous contest in the scientific world between the corpuscular and the undulatory theory of light. It is not so commonly known that the wave theory was the first to receive the support of eminent men of science. No theory worthy of the name existed prior to the time of Huygens. At a meeting of the French Academy of Sciences in 1678, and in the presence of astronomers Roemer and Cassini, Huygens read a remarkable paper on the wave theory of light. Bradley, the Astronomer Royal of England, had already confirmed Roemer's conclusion from observations on Jupiter's inner satellite that the propagation of light is gradual and not instantaneous. Thus two methods of determining this constant of nature had been discovered—Roemer's by the eclipses of Jupiter's satellite, and Bradley's by the phenomenon now known as aberration. In 1690 Huygens published his *Traité de la Lumière.* In this he developed the principle relating to the propagation of waves which continues to be known by his name to this day. It assumes that each point of a wave-front becomes a new center of disturbance for secondary waves, which coalesce into a succeeding wave-front. Huygens definitely assumed the existence of an ether, and explained reflection and refraction by methods which are still current in physical litera-

ture. He even gave constructions for the path of the ordinary and extraordinary rays in Iceland spar and showed that both are polarized. But a fatal defect was his assumption of longitudinal vibrations and his inability to give a satisfactory account of rectilinear propagation.

Newton was familiar with the undulatory theory and distinctly recognized its capability of explaining the colors of thin plates. The theory, he says, "is sufficient to explicate all the ordinary phenomena of those plates or bubbles, and also of all natural bodies, whose parts are like so many fragments of such plates." He nevertheless rejected it in favor of his corpuscular theory, and by his powerful authority biased the minds of physicists for a whole century. The corpuscular doctrine held sway against the arguments of Hooke, Huygens, Young and Fresnel till Foucault devised the crucial experiment to determine whether the velocity of light in water is less or greater than in air. The Newtonian theory required that it be greater; the undulatory theory that it be less. Nature said it is less, and the Newtonian theory retired into the background.

Maxwell, with great penetration and power, laid the foundations of a fundamentally new method of regarding the undulations of light. It remained for the lamented Heinrich Hertz to confirm the Maxwellian theory by a series of the most brilliant experiments of modern times. Since then light has taken its place as an electromagnetic phenomenon; and the rapid extension of the area over which electromagnetic waves of long period may be recognized has finally enabled them to bridge the Atlantic.

It must not be inferred, however, that the undulatory theory of light has been abandoned or superseded. The electromagnetic theory of light is only a modification of the wave theory; it describes something of the mechanism of wave motion in the ether, and classifies the energy in light as electromagnetic in character. It is now possible to produce waves in the ether indefinitely longer than those affecting the eye as light, and to recognize them by appropriate receiving apparatus. Modern discovery consists not so much in the discovery of long ether waves as in the recognition of their existence and the means of detecting them. The wireless messages of Marconi, wonderful as they are, are but

feeble imitations of those incessantly pouring in upon us from the sun. These have dashed the earth with gorgeous colors and dotted the oceans with the greenest of isles. Their swift-winged messages have brought to man some knowledge of other worlds and other suns than ours.

A scarcely less instructive change of physical theory took place during the past century regarding the nature of heat. Able men had not been lacking who had suggested a theory dimly resembling the one held at the present time, but the materialistic doctrine of heat was still generally held by both physicists and chemists, along with its congener, phlogiston. Descartes, Bacon, Hobbs and Boyle all suggested that heat and motion were intimately associated. Indeed Newton himself asked, "Is not heat conveyed by the vibrations of a much subtler medium than air?" Unfortunately the great Cambridge philosopher decided in favor of the materialistic theory, the adoption of phlogiston followed, and then the bald doctrine of material caloric after Newton had long been in his grave.

You are all familiar with the first staggering blow at the doctrine of caloric delivered by Count Rumford in 1798. His noble contribution to the science of thermodynamics counts for so much that we are disinclined to believe he was a Tory in North Woburn (especially that the Revolutionary War is now over and England ungrudgingly acknowledges that we were right); and we are almost ready to forgive his desertion of wife and child, when he fled to England to become a somewhat inactive enemy of the land of his birth. We must not forget either that Rumford was instrumental in founding the Royal Institution in London. That establishment for research in Albermarle street has been prolific in great discoveries. The mere mention of such names as Davy, Faraday, Rayleigh, and Dewar is sufficient to call up a long line of the most splendid contributions to science, which have been freely given to the world by this same institution for research. Rumford's strong argument, derived from the continuous production of heat in boring cannon, was to the effect that whatever could be obtained in an apparently inexhaustible quantity, when a blunt plunger was turned against friction in a bronze cannon, could not be material. The youthful Davy, then only

twenty years of age, clinched the argument by showing that ice could be melted by friction against ice. Davy, with a modesty becoming his youth, hesitated to draw the logical deduction from his experiment which it abundantly justified till some twelve years later. The caloric theory survived, strange to say, for more than half a century after the experiments of Rumford and Davy had condemned and disproved it. As late as 1856, it received the preference over the dynamic theory in an article on "Heat" in the Encyclopædia Britannica.

When, however, the doctrine of the Conservation of Energy emerged into the view of those having clear scientific vision, it was perceived that heat is neither material, nor is it the mere motion of material particles; not "a mode of motion," but the energy of that motion. Heat is energy convertible into all other forms of energy, and the final form which all energy assumes in the process of dissipation. Hence the great work of Joule and Rowland in determining "the mechanical equivalent of heat," one of the most important constants of nature which the mind of man has evolved as a corollary from the doctrine of the Conservation of Energy. May I take occasion in passing to remark that, since heat is energy and not a material, it is unscientific to apply to it the word "temperature." Much that has been written on the subject of the application of thermodynamics to the very modern subject of physical chemistry contains expressions based on the antiquated concepts of the caloric theory. Not a few writers, including Nernst and his school, speak of a quantity of heat falling from one temperature to another, or of raising a quantity of heat from one temperature to a higher one, as if heat were a substance called "caloric." It is indeed time that eighteenth century conceptions about heat were eliminated from treatises and textbooks.

The mention of physical chemistry brings to mind many changes that have taken place in physical concepts within the past two decades. Just twenty years ago Helmholtz said to the writer, as the latter was about to leave his laboratory, that the most promising field of labor was then on the border land between physics and chemistry. Subsequent events show that Helmholtz himself was at that time at work in this field, and at this distance of time his words seem prophetic.

The old formal scholastic distinction between physics and chemistry has disappeared. It is no longer true in any sense that physics is concerned with the molecule, while chemistry has to do with the atomic constitution of matter. So far afield have we gone from this old hard and fast division that the modern physicist does not pause at atoms even. He has now to deal with corpuscles or electrons, whose mass is perhaps little in excess of 1/1,000th of an atom of hydrogen. The brilliant work of Professor J. J. Thomson in this field has given rise to new concepts of matter, and has taught us that there is more in an exhausted receiver then we have hitherto dreamed of in our philosophy.

Knowledge of the properties of matter has been enormously extended in two directions, the one in high vacua, and the other at low temperatures. The revolutionary discoveries of Sir William Crookes, beginning about 1875, on electric discharges in high vacua have opened a new world of the most bewitching interest. We now have Lenard rays, Roentgen rays, Becquerel rays, and radio-active substances emitting radiations of most pernicious activity. It has thus been ascertained that mankind has been living in the midst of a multitude of unsurpassed wonders and of properties that no one suspected.

The expression "fixed gases" has not yet faded from our memories. I well remember the wide reputation gained by my old professor of chemistry in college because of his success in liquefying carbon dioxide a short time previously. The solidification of this substance is now a common lecture room experiment, and the "fixed gases" then known have all followed in the train of carbon dioxide. Every gaseous body but one definitely known to the chemist has now been reduced to the solid state. For the last dozen years Professor Dewar has been engaged at the Royal Institution in London on these low temperature experiments. Ten years ago I saw him turn a spigot and out of it flowed liquid oxygen mixed with solid carbon dioxide, from which it was separated by passing the extremely cold liquid through an ordinary filter paper. Even then he was able to liquefy air under atmospheric pressure by means of the low temperature obtained by the evaporation of liquid oxygen in an exhausted received. Hydrogen has followed, not to the point of liquefaction only, but to the state of

a clear ice-like solid at a temperature only *thirteen degrees* above the zero of the absolute scale, or at a temperature of 260 degrees below the zero of the Centigrade scale. Its density in the liquid form is only one-fourteenth that of water, and the only solid that will float on it is pith. Its specific heat, on the other hand, is five times that of water, and its coefficient of expansion is ten times that of a gas. It does not conduct electricity, strange to say, in either the liquid or the solid state. It is therefore non-metallic, and it is also slightly diamagnetic. The study of the properties and chemical relations of hydrogen led great physicists and chemists like Faraday, Dumas, Daniell, Graham, and Andrews, to entertain the view that in either the liquid or the solid state it would exhibit metallic properties. The case of hydrogen shows, as Dewar says, that "no theoretical forecast, however apparently justified by analogy, can be finally accepted as true until confirmed by actual experiment."

Another revision of physical concepts, which still remains within the realm of theory, is the modern doctrine of osmotic pressure, and the related doctrine of electrolytic dissociation. The theory of the solution of a solid in a liquid solvent remained in a chaotic state up to a period fifteen years ago, when van't Hoff showed that when sugar is dissolved in water the dissolved particles follow the laws of Boyle and Gay-Lussac for gases; in other words, we may apply to the sugar in solution the gas equation, $PV = RT$, and may demonstrate that if P is the osmotic pressure and V the volume containing a gram-molecule of the sugar, R has the same value as in the case of a gas, that is, about 83,000,000. Such a remarkable result can scarcely be a coincidence. Whether great molecular mobility is given to a substance by causing it to assume the gaseous form, or by dissolving it in a proper solvent, it follows in both cases the same laws as regards the relations between volume, pressure and temperature.

I have stated the principle too broadly, because substances in solution, which conduct electricity and undergo electrolysis invariably exhibit a larger osmotic pressure than they should to conform to the gas law. This increase is accounted for by the dissociation into electrically charged ions, which the substance undergoes in solution, an ion exerting the same osmotic pressure as a molecule.

Van't Hoff expressed the relation between gas pressure and osmotic pressure as follows: "The pressure which gas exerts at a given temperature, if a definite number of molecules is contained in a definite volume, is equal to the osmotic pressure which is produced by most substances under the same conditions, if they are dissolved in any given liquid." But the "most substances" of van't Hoff, Arrhenius showed do not include many aqueous solutions in the sense that these latter exert a much greater osmotic pressure than is required by the gas law. Hence Arrhenius made a distinction between active and inactive molecules in solution, the active molecules including those whose ions are independent of one another in their movements. The remaining molecules, not dissociated into independent ions, are inactive. He then proceeds to show that van't Hoff's law holds not only for most, but for all substances, even for those which had hitherto been regarded as exceptions, that is, electrolytes in aqueous solution.

A corollary of this law is that the active molecules alone conduct electrolytically, the inactive molecules taking no part in the process. In other words, conductivity is a property of the charged ions into which the dissolved substance is dissociated.

The theory of electric conductivity in electrolytes has undergone modifications in successive steps or stages. Very soon after the electrolysis of a compound liquid had been effected, Grothuss, then only twenty years of age, proposed the theory of electric conductivity in liquids which bears his name; it was in a paper published at Rome in 1805, and bearing the title "Memoir on the decomposition of water and of other bodies, which it holds in solution, by the aid of galvanic electricity." The theory involves alternate separation and recombination of molecules. To accomplish this segregation of oxygen and hydrogen, for example, a definite E. M. F. must be applied to the solution by means of the electrodes. A smaller potential diffenerce than that required to effect the segregation would not produce any electrolysis nor the flow of a current. But it was afterwards shown, as Clausius pointed out in 1857, that even the weakest E. M. F. produces a current through an electrolyte and that it follows Ohm's law. Hence the modification of the Grothuss theory proposed by Clausius that the ions of substance in solution are not permanently

united with one another, but a few of them are always present in a temporarily uncombined state, and wandering about till they again combine with other partners. This temporary dissociation Clausius conceived to be due to the agitation of heat, and he gave cogent chemical reasons in support of his hypothesis. These free ions are then present in a solution to conduct a current when the potential difference is below the value required for actual visible decomposition.

When the voltameter is composed of metallic electrodes immersed in a salt solution of the same metal, copper electrodes in copper sulphate solution for example, the current is simply proportional to the potential difference between the electrodes, no sudden change in its value is observed, and the metal is simply transported across from one electrode to the other. If, however, at least one of the products of the electrolysis is a gas, which occurs when the anode is platinum, then the appearance of the liberated gas when the potential difference reaches a well-defined value, is a signal for a rapid increase of the current and of the visible decomposition. Since work must be done against atmospheric pressure when a gas is liberated, the E. M. F. must have a corresponding determinable value before the required work can be accomplished.

From an electrical point of view the Clausius modification of the theory of Grothuss appeared to answer the requirements. But the study of the conductivity of electrolytes, by Kohlrausch especially, showed that the molecular conductivity, or the conductivity of a gram-molecule of the substance in a solution placed between plate electrodes one centimeter apart, depends on the dilution; the greater the dilution, the greater the molecular conductivity. This fact demanded an advance on the theory of Clausius. The advance step consisted in assuming that the dissociation which Clausius conceived to be casual and indeterminate in amount, is permanent and occurs when the substance is dissolved. Hence the more dilute the solution, the larger the proportion of molecules which undergo dissociation and become *active* in the sense in which Arrhenius used the word. At extreme or infinite dilution, all the molecules in the solution are dissociated into ions, some positively charged and the rest negatively.

The current through an electrolyte consists of the sum of the positive and negative charges actually carried through the solution by the migration of the positive ions toward the cathode and the negative ions toward the anode.

The theory of electric conductivity through solutions is intimately connected with the theory of a voltaic cell. It has thus come about that the modern dissociation theory has led to an entirely new view of the mechanism in a primary cell, and especially the origin of its E. M. F. A heated controversy was kept up for three generations over the origin and seat of the E. M. F. in a voltaic cell. I know of no other dispute so persistent and long sustained, unless it be a Kentucky family feud. Volta's theory that the origin of the E. M. F. is at the contact of the two metals had able supporters especially in Germany, where the names of Poggendorff, Fechner, and Ohm were names to conjure with. On the other hand Fabroni, Wollaston, Ritter, Becquerel, de la Rive and the great Faraday held that the source of voltaic electricity is chemical action. Then came the doctrine of the Conservation of Energy and the immediate conclusion that mere contact of metals could not give rise to the supply of electric energy which a cell is able to furnish. It will be observed that when Helmholtz, then only twenty-six years of age, presented his paper on "Die Erhaltung der Kraft," or as we now express it, The Conservation of Energy, for publication in *Poggendorff's Annalen,* it was rejected by this same Poggendorff who had persistently held to the contact theory. Whether Poggendorff was then the responsible editor of the journal, I am unable to say. He lived for thirty years after this time.

Helmholtz's paper was read before the Physical Society of Berlin in 1847, and was published the same year in pamphlet form. It attracted little attention for six years when, strange to relate, it was vigorously attacked by Clausius, who lived long enough, however, to see his error and to recognize the greatness of Helmholtz.

After the introduction of the principle of the Conservation of Energy, Thomson applied it to the voltaic cell and calculated the E. M. F. on the basis that the electric energy evolved equals the chemical energy transformed. From the point of view of

energy, a voltaic cell is a device for the direct conversion of potential chemical energy into the energy of an electric current. The question arose whether all the chemical energy transformed in a voltaic cell is thus converted into electrical energy? Thomson and Helmholtz at first answered the question in the affirmative, and the principle of equating the two forms of energy was thereafter known as the Thomson principle. According to this view it is a simple matter to calculate the E. M. F. of any given combination from the heats of formation of the compounds undergoing chemical change. The quantity of electricity transported through the cell when one gram-equivalent of zinc enters into solution and a gram-equivalent of other substances undergoes a concurrent change may be calculated from Faraday's laws of electrolysis. It is 96,540 coulombs. This quantity multiplied by the E. M. F. of the cell equals the electrical energy given out while one gram-equivalent of zinc goes into solution. If this product is placed equal to the algebraic sum of the heats of formation of all the chemical changes involved in the cell, the E. M. F. is readily obtained from the equation. Thus the heat of formation of a gram-equivalent of zinc sulphate, according to Berthelot, is 121,000 calories; of copper sulphate, 95,700 calories. The difference is 25,300 calories. Then the reaction in a Daniell cell may be written

$$Zn + CuSO_4 = ZnSO_4 + Cu + 25{,}300 \text{ calories.}$$

$$\text{Further, } EQ = 25{,}300 \times 4.19 \text{ calories,}$$

where Q equals 96,540 coulombs. From this equation E is 1.098 volts, the E. M. F. of the cell. The value of the E. M. F. of the Daniell cell calculated in this way agrees very closely with the observed value. It was soon found, however, that other cells did not show such good agreement with the theory. In some the E. M. F. is smaller than the calculated value, and in others it is larger. Finally, Willard Gibbs in America and Helmholtz in Germany independently expressed the true relationship between the chemical energy transformed and the electrical energy given out. The Gibbs-Helmholtz equation may be conveniently written as follows:

$$E = \frac{H}{q} + T\frac{dE}{dT},$$

in which H is the sum of all the heats of formation expressed in mechanical measure, q is the quantity of electricity required to transport one chemical equivalent of any substance (96,540 coulombs), T is the absolute temperature, and dE/dT the temperature coefficient of the E. M. F. of the cell. It is obvious from this equation that E is smaller than the E. M. F. calculated from thermal data alone whenever the temperature coefficient is negative; and it is larger when the temperature coefficient is positive. In the former case only a portion of the transformed chemical energy appears as the energy of the current: the remainder heats the cell. In the latter case, the energy given out by the cell is in excess of the chemical energy transformed, or the cell converts some of its heat into electrical energy, and so cools in action.

The Gibbs-Helmholtz equation represents our most assured knowledge of the relation between the chemical, electrical, and thermal quantities involved in a voltaic cell, and it has been fully established by experiment.

It has also been demonstrated that the temperature coefficient of a voltaic cell is equal to the sum of all the thermo-electromotive forces, taken with their proper sign, at all contacts of dissimilar substances in the cell. For example, the thermo-electromotive force between zinc and a solution of zinc sulphate is directed from the solution to the metal. The same is true of copper and copper sulphate, while the thermo-electromotive force between equi-dense solutions of the sulphates of zinc and copper is practically zero. If, therefore, a Daniell cell be so constructed that one side or electrode may be heated independently of the other, it will have a positive coefficient if the positive electrode and the solution about it be heated, and a negative coefficient if the negative side alone be heated. This follows from the fact that the direction of the E. M. F. of the cell as a whole is from the zinc to the copper through the cell. Hence the thermo-electromotive force at the copper electrode is in the same direction as that of the cell, while that at the zinc electrode is in the opposite direction. These two thermo-electromotive forces are very nearly equal to each other, and the temperature coefficient of the Daniell cell as a whole is therefore very small. The same method applies to other cells.

It thus appears that the heat generated or absorbed, corres-

ponding with the sign of the temperature coefficient, may be localized in the cell. For example, in the Daniell cell the passage of a current generates heat at the zinc electrode, where the current flows against the thermo-electromotive force at the surface of the zinc; at the same time heat is absorbed at the copper electrode because the thermal E. M. F. there is in the same direction as the current. A difference of temperature is thus established between the two sides of the cell, which in a given time is proportional to the first power of the current. These statements have been fully established experimentally. If the quantities of heat generated on the one side and absorbed on the other are equal to each other, then the temperature coefficient of the cell is zero and the chemical energy transformed equals the electrical energy given out.

The Gibbs-Helmholtz equation, modified as described, is a fairly complete expression of the voltaic cell from an energy point of view. It needs only the further addition of expressing the heat of formation of the chemical compounds involved as a function of the density of the solutions.

The Nernst theory of a voltaic cell is based first of all on the theory of osmotic pressure developed by van't Hoff. To this theory it adds the assumption that metals exhibit a tendency to go into the ionic state when immersed in an electrolyte. A supposed analogy is found in the tendency of liquids to evaporate, the evaporation in a closed space continuing until the vapor pressure is equal to the tendency of the liquid to pass into vapor. In the same way the osmotic pressure of a solution saturated with metallic ions may be looked upon as a measure of the "solution pressure" of the metal in contact with it. This "solution pressure" of Nernst is supposed to measure the tendency of a metal to pass into free ions in an electrolyte. If now a metallic ion passes from a solution pressure P into the state of a free ion under an osmotic pressure p, then Nernst conceives that the work done is the same as when a gas passes from the one pressure to the other. The well known formula for the work in the case of a gas is $RT. \log P/p$. This is the work done at one electrode when a gram-equivalent of metal passes

into solution. Substituting the value of the gas constant R, and passing to common logarithms, we get

$$E = 0.0002\,T \log \frac{P}{p}.$$

This expression applies to metals whose valence is one. If the valence is n, and if we take into consideration both electrodes, we have

$$E = 0.0002\,T \left(\frac{1}{n} \log. \frac{P}{p} - \frac{1}{n'} \log \frac{P'}{p'}\right)$$

as the equation for the E.M.F. due to solution pressure and osmotic pressure only. If two electrolytes are employed, a small effect may be produced at the contact of the two.

It will be observed that both the Gibbs-Helmholtz and the Nernst formulas involve the doctrine that the seat of the E.M.F. of a voltaic cell is at the contact of dissimilar substances in the cell. Neither is, however, a contact theory, but both reason from the theorems of thermodynamics. The two formulas represent two ways of approaching the problem. They are not antagonistic, but complementary rather. Nernst's formula gives a somewhat more detailed insight into the mechanism of a cell, but it involves a number of hypotheses which the most ardent admirer of the theory can hardly claim to have been established by experiment. The Gibbs-Helmholtz formula, even when including the localization of the heat effects, rests on a secure basis of experimental facts.

The Nernst formula gives no definite account of the temperature coefficient of a cell, nor of the relation of this coefficient to the electrical energy evolved. The thermodynamic method of Gibbs and Helmholtz furnishes the most secure foundation for the investigation of a cell from the point of view of energy changes, without the assumption of any hypotheses, and without exposing to view the exact mechanism beyond the application to the problem of thermo-electromotive forces.

"And what shall I more say? for the time would fail me to tell of Gideon, and of Barak, and of Samson, and of Jephthah; of David also, and of Solomon, and of the prophets." I will only

recall to your minds that the superficial distinctions between electricity developed by friction, by voltaic cells, by heat, and by electromagnetic induction have all gradually disappeared, since a condenser may be charged or a current be set flowing by electric pressure, however produced. All the phenomena formerly produced by electrostatic machines are now produced by induction coils or by alternating currents of high potential. In fact, many new phenomena have been added by the high frequency discharges obtained by alternating currents. Lightning has, so to speak, been analyzed into the "steady strain" and the "impulsive rush" discharges of Sir Oliver Lodge, with attendant oscillations along a well-worn track till the energy is dissipated in heat. Hence the interesting resonance effects, which bring out a striking analogy between stationary waves in sound and stationary waves or surges of electricity.

Again, in magnetism, the crude theory of a magnetic fluid, adhering like a liquid drop to the poles of a magnet, has given place since the time of the immortal Faraday to the conception of magnetic induction, and lines of force. These lend themselves to experimental investigation to such an extent that today we may design a magnetic circuit to the minutest detail with nearly or quite the same approach to accuracy that is possible with an electric circuit. The law of the magnetic circuit, thanks to Rowland and others, has now taken its place alongside the law of the electric circuit as established by Ohm.

Note, also, how our friends and fellow workers, the mathematicians, have been obliged to give up their favorite "action at a distance" doctrine. Faraday and Maxwell taught them that no action takes place at a distance without the agency of an intervening medium. As soon as the cannon-ball theory of light and radiant heat had been relegated into a decent oblivion, the necessity arose for a revision of all the physical theories of action involving the law of inverse squares. In fact this law fails except under ideal conditions, and especially in the case of gravitation. Indeed gravitational astronomy has not kept abreast of modern physical astronomy as represented by such eminent workers as Pickering of Cambridge and Campbell of Mt. Hamilton. Great renown awaits the physical astronomer who will demonstrate be-

yond doubt whether gravitation acts through the medium of the ether, and whether it involves the element of time in transmission.

Finally, a lesson for the present may be drawn from the history of theory in the past. Theories are only helps or scaffolds. They are necessary working devices which aid in the advance of the edifice, and finally disappear like the staging. Use them only as props and temporary expedients, not until the whole edifice is finished, but until some grand arch is completed, some minaret or tower emerges against the clear sky, or the light streams in through some noble window.

It is often darkest just before the dawn. Sometimes we emerge into the bright light with a suddenness that blinds before the eye adjusts itself to the new illumination. One dreary day in April I took the train in Switzerland over the St. Gotthard route. We entered the north end of the tunnel with a clouded sky and snow flakes swirling through the air. Ten minutes passed in the darkness a thousand feet beneath the village of Andermatt, fifteen, seventeen, and then the train ran out on the Italian side of the great divide—into a burst of sunshine and clear sky and white-capped Alpine peaks and tempered winds and the pale green of olive groves. So sudden was the transformation that an involuntary exclamation of surprise ran through the train. The experiences of the past twenty years warn us that we must be prepared for similar surprises in the illumination that physical science is shedding on the world of nature. It seems to us that we are no longer walking by the light of the moon, but that the sun has already risen in its splendor. What shall the noonday be?

MATTER AND METHOD IN PHYSICS TEACHING.

BY R. H. CORNISH.

First Assistant, Wadleigh High School, New York City.

(*Concluded from page 333.*)

It is frequently urged that physics for culture should be something different in its scope and method from physics for college; that physics for those preparing for college should be different from physics for those not preparing. To my mind this distinction is unnecessary and unwise. Physics for college and physics for culture seem to me one and identical, just as geometry for college and geometry for culture are identical, both as to subject-matter and results obtained.

It seems hardly necessary to specify particularly the topics that should form the subject matter of a year's course in physics. Text-books published within the last year or two are as a rule smaller in volume than those published ten years ago. It seems as if authors were beginning to consider that not everything could be mastered in one science in one year and were inviting the criticism that they probably knew more than they had written in the book. I think a year's course should include the elements of all the great topics in physics, viz.: Mechanics of solids, liquids and gases, heat, light, sound, electricity and magnetism. I do not think it makes any great difference in what order these topics are taken up. It is conventional to place mechanics first and probably most schools begin with that subject, but I have obtained good results by beginning with light. In my present position I think light is a much more profitable topic for the girls than some others, electricity, for example. Prof. Tyndall speaks of the interest he aroused in his class by the problem: "How large a mirror placed against a vertical wall does a lady need in order to see her whole figure at one glance?" I can testify that this is still the favorite original problem at the girls' high-school. It lends itself very readily to home work.

Physics may be taught by text-book and recitation, by lec-

ture and demonstration, or by laboratory method. The judicious teacher in the secondary school will probably combine all these methods in varying amounts, as circumstances demand.

The text-book and quiz or recitation are indispensable for fixing the facts in the pupil's mind and helping him to word the expression of his ideas in clear language. But no good teacher at the present day would adopt this method exclusively. The study of a text-book of physics should be of great assistance, but the book will be very dry if the study of it is not enlivened and illustrated by the demonstrations before the lecture table. We frequently hear this method described as old fashioned and behind the times, and certainly no teacher would deliberately choose this method if another were possible, but it must be said that many successful physics teachers began their study of physics in this way, and under the inspiration of an enthusiastic teacher who had little or no apparatus, were able to obtain a fair knowledge of physical principles and laws. Joseph Henry, at the age of 15, entered the shop of a watch maker as an apprentice, although his chief ambition then was to excel as an actor and dramatic writer. Accidentally he came across *Gregory's Lectures on Experimental Philosophy,* the perusal of which created a love for science. Some have had even less than this. The ideal method will, it seems to me, combine the study of a text-book, accompanied by recitations, quizzes on the book, with explanations and demonstrations by the teacher and will include a certain amount of individual laboratory work. The pendulum of pedagogic practice has in the past swung from one side of the arc of method clear over to the other. A few years ago the favorite method in all sciences was that of the laboratory in which the student, under directions from the teacher, was set to rediscover the laws of nature. Text-book was abandoned and the student was expected to obtain his knowledge at first hand by the true method of asking questions of nature and very carefully listening to her answers. Conservative teachers soon found what might have been expected, that the untrained and immature mind could not rediscover nature's laws. The effort was attractive, but the result disappointing. Valuable as I consider the laboratory it must be confessed that unless very careful supervision is exercised a great deal of time is wasted in so-called

laboratory work, and this work is apt to degenerate into play, or from want of direction into aimless, discouraging and profitless effort on the student's part. The proper balance between laboratory work, recitation and demonstration is a most important question for the teacher to decide. The object of each part is the same, but the aim of each is different. The aim of the recitation is to discover how clearly the student has mastered the ideas, principles and laws which he has studied in the text-book, on the demonstration table or in the laboratory. The lecture and demonstration explain and illustrate those laws which the student cannot readily himself discover or illustrate. The demonstrations will often use more complicated apparatus than can be entrusted to the student or will illustrate qualitatively what the student will for himself undertake to discover quantitatively. The aim of the laboratory work is to make knowledge real and vivid in the experience of the student. In order to accomplish this purpose individual work by classes or in small groups is very desirable. There are several conditions in which laboratory work can not be done with success. First, if the classes which come to a teacher are so large and unwieldy that proper supervision can not be given, or if the room devoted to this part of the work is so crowded that pupils do not have elbow room in which to work satisfactorily, laboratory work becomes very difficult if not impossible.

I believe the laboratory work may be and ought to be the most valuable part of the physics course and no high-school that pretends to teach physics should abandon it. The conditions which temporarily might obtain that would make laboratory work impossible ought sooner or later to be rectified so that the pupil may have the satisfaction and pleasure of doing with his own hands, of sighting with his own eyes, of measuring and weighing with apparatus, which for the time is his own. From exercises carefully planned and done by the student himself there should come the highest satisfaction and greatest mental value.

What are the results of this method of laboratory work? Well, some of them are surprising. I asked a girl how to make a barometer. She replied (using the language of the book but omitting one word): *"First, take a bath."* The book said take a mercury

bath, which is the name of a flat dish for holding mercury. The answer seemed to amuse the other girls.

You remember that the forts of a sound wave or a wave of compression are a condensation or crowding together and a rarefaction or pulling apart of the air particles. When I asked this question of one girl her reply was: "A *condescension* and a *refraction.*"

An important detail of the laboratory work is the record which the student makes of what he does, or what he sees the teacher do on the lecture table. A laboratory note book properly attested is demanded by most of the colleges which require physics. The note book should contain a record of the object of the exercise, should enumerate the apparatus used, should contain the measurements and calculations made and a statement of the result finally obtained.

Laboratory exercises may be of three kinds: (1) Those whose object is the verification of a law. The law has presumably been learned from the text-book or the teacher. Typical of this class may be mentioned the laws of accelerated motion and the laws of the pendulum. (2) Those exercises whose object is the determination of a physical constant. Determinations of specific gravity, of specific heat, the coefficient of expansion of a metal rod, of the coefficient of friction between two surfaces, of the index of refraction, of the relative resistance of different kinds and sizes of wire, all illustrate problems of this sort. (3) Exercises whose object is the discovery and statement of a law. Of this sort may be mentioned Archimedes' Law, the law of flotation and the law of the reflection of light. These exercises must have simple results or the teacher will find that inevitably the result must be told to the student. In exercises of the first and third class we have the opportunity to illustrate the difference between inductive and deductive physics teaching. Exercises of the third class are inductive. The student performs the exercise not knowing the result. The exercise may be stated in the form of a question, thus: "What relation exists between the weight of a floating object and the weight of the water displaced," or "What is the size, position, appearance and kind of image formed by a plane mirror?" In these cases the pupil can be carefully led to

formulate the law from the results of his laboratory work and thus the teaching may be truly inductive. In exercises of the first class the process is deductive. The pupil is told, or has learned, the law and his laboratory work consists in verifying it. For example, to derive the law of the inverse squares in light by an inductive process is possible, but seems to me a waste of time. It is certainly quicker, and in the end, I think, just as effective, to state the law and then illustrate it by the lantern. In the conduct of laboratory work two methods are in common use. These I may call the class method and the individual, or group, method. In the individual method each student, or group of two (rarely three), is given a problem to work out experimentally with apparatus specially set up for the purpose. The laboratory may contain ten or a dozen different sets for the solution of as many different problems. Each group has a different problem. Generally printed directions are attached to each set, telling the pupils what to do. The teacher must have explained the nature of the exercise and something of the method of manipulation. One or more laboratory assistants, dependent upon the size of the class, are needed. This method, which is used in many high-schools, has always seemed to me to be essentially a college method, and ill adapted to secondary schools and immature pupils. The class method of laboratory work requires duplicate apparatus. Separate pieces must be provided for each pupil or each small group. By this method the whole class can be led by direction, question and suggestion to the desired result. After the exercise has been performed a class discussion can be held while the problem is still fresh in the student's mind. These exercises are, with two or three exceptions, quantitative in character. The lecture table demonstrations, on the other hand, are mostly qualitative. They are the outcome, in my case, of 15 or more years' experience and of experimenting with different methods. Quite recently this whole procedure has been called in question by a high authority. I refer to Pres. G. Stanley Hall.

In an address before the N. E. Association of Colleges and Preparatory Schools, and repeated substantially before the Conference of Educational Workers in New York, he said: "Boys of this age [the middle teens] want more dynamic physics. Like

Maxwell when a boy they are interested chiefly in the 'go' of things. Those with aptitudes for physics want and need wide acquaintance first, with tops, kites, and other physical toys, then with clocks, dynamos, engines, machinery, with some experience in running it and using tools; in looking into ,taking apart and putting together almost anything that will go. Moreover, exactness comes relatively late in the development of the youthful mind, as it did in that of the race, long after interest in general principles and especially forces. The normal boy of the middle teens is often a walking interrogation point about ether, atoms, nature of electricity, X-rays, motors of many kinds, with a special gravity of mind toward frontier questions, where the great masters know as little as he. He would like to see hundreds of demonstrative experiments made in physics, and the liberty to repeat most of them himself without being bothered about mathematics. Moreover, he has a veritable passion for brief stories of great men. The heroology of the history of physics, if rightly applied, might generate a momentum that would even take him through the modern course. He is essentially in the popular science age. He wants great wholes, facts in profusion, and very few formulæ."

Now Pres. G. Stanley Hall is a thoughtful man, and such an utterance as that just read requires careful examination. It amounts to a condemnation of quantitative work, such as has been slowly elaborated and adopted in many of our high-schools. That kind of physics teaching known as "Harvard Physics" is criticised. There are several points in this quotation which every physics teacher can take to heart and profit by. (1) Qualitative or demonstrative experiments should be used freely by the teacher. To this I have already alluded. They are indispensable to the proper presentation of the subject. Under suitable direction and careful guidance some of these demonstration exercises may become profitable laboratory exercises. But I think it is true, as pointed out by Prof. E. H. Hall, of Harvard, that "qualitative facts are apt to be very obvious or very obscure. A stone falls to the ground. Everybody knows that. Why does the stone fall to the ground? Nobody knows that. How fast, under what quantitative law, does the stone fall? That is the kind of question we can take up in the laboratory with the least likelihood of wasting time and effort,

although that particular exercise is too difficult for ordinary school laboratories." (2) The great names in the history of physical science should be more frequently referred to, and their contributions to our knowledge should be explained. I think this is commonly neglected. The history of physics cannot be formally taken up nor should it be, but the pupil should at least know the names of Archimedes and Galileo, of Newton and Pascal, of Franklin and Henry, of Faraday and Tyndall and many others, whose names are immortal. (3) The use of simple tools should be encouraged and also the desire to understand the mechanism of the machines which come before the pupils. But to attempt to substitute the workshop for the laboratory would, in my judgment, be a serious mistake.

As was to be expected, the criticism on physics teaching was not allowed to pass unchallenged. President Eliot replied that the results of the kind of physics teaching which had been encouraged and insisted upon by Harvard University had been quite satisfactory to the university authorities and that the work done by the schools was improving each year. He also said that one great aim of physics teaching was training the observational powers of the pupil and that quantitative laboratory work was much better for this purpose than any other kind.

But the most complete defense of the quantitative method and criticism of the method urged by Pres. Stanley Hall that I have seen was made by Prof. E. H. Hall, of Harvard University, in an address read before the Physics Club of New York and published in SCHOOL SCIENCE (Vol. II, p. 57). This very interesting address is entitled "The American Physics Teacher's Opportunity."

What shall be said of the qualifications of the teacher of physics? They are exactly the same as the qualifications of the successful teacher of any other branch. A thorough knowledge of the subject and of related subjects, a patience never failing, an instant readiness to appreciate the pupil's difficulties and to put yourself in his place, and tact in winning and keeping the pupil's confidence—these are the necessary requirements for the physics teacher or for any teacher. One thing the physics teacher needs in preëminence—the willingness to spend an enormous amount of time in the endless detail of experimentation. Slipshod experi-

ments, efforts that do not succeed, produce a bad impression and weaken the respect of a class for a teacher. The art of experimenting must be learned by repeated, careful and long continued trial. But the results of this repeated effort will more than repay the teacher. We have had recently in Montclair, N. J., an evening devoted to Modern Heroes. The heroes whose deeds were exploited and who were held up to our admiration were the firemen of New York City and the members of our government life-saving service, which extends its operations along our ocean border. How our hearts thrilled as Mr. James Sheffield, one of the fire commissioners of New York, and Major Piper, of Washington, told in simple language, story after story of the deeds of noble daring and heroic life-saving effort made by the firemen and the surfmen in their regular line of duty. Now in comparison with such lives as these how tame and uneventful must seem the life of the teacher. How often have I wished that I was engaged in some business in which I could have immediate and ocular evidences of the results of my work, such as a carpenter or a paper-hanger has. But such is not the case. The results of the teacher's labors are found in the mental and moral improvement of the pupil. Quick returns from mental investments made by us in others we very rarely have. If, however, we can see a slow but sure growth, a steady but sure increase in mental power, and chiefest a moral growth by which the boy or girl gives evidence of becoming more patient, more thoughtful, more self-controlled, we may rest in a measure satisfied. Your pupils will soon forget the physics and mathematics and Latin which you teach them, but if you have been master of the subject and of them, have been patient, interested and devoted, they will never forget *you*.

How have our own teachers influenced us? I think in two different ways. First, by quickening our enthusiasm in some branch of study by their own enthusiastic devotion to it. How vivid and delightful is the memory of the geological excursions we took with old Prof. Dana, then 70 years old! At that age he was still the leader of the boys in climbing hills and rocks and in leading his pupils to places where he found material to illustrate his geological story. But secondly, and more important, our teachers have impressed us by the unconscious influence of their lives and character.

"After all," says Gilman, "a great teacher is not to be measured by his learning but by his example."

The life of the scholar and teacher may not be exciting and eventful, but in its dignity, its serenity, it may leave little to be desired. As I think of Dana and Porter and Woolsey and Newton, the thing that impresses me most is not their learning, although that was great, but their simplicity, their elevation of soul, their sweetness of spirit, their purity of life. Happy the boy or girl who comes under such influences and who profits by it! Happier still that teacher who can worthily exert it!

THE THEORY OF ELECTROLYTIC DISSOCIATION.

BY LOUIS KAHLENBERG, PH. D.

Professor of Physical Chemistry, University of Wisconsin.

The teacher of natural science is frequently confronted with the question as to how much prominence should be given to this or that scientific theory. It is well recognized that theories are the changeable, the ephemeral part of science; that they are really only tools by means of which the truth, the facts which are eternal, may frequently be discovered, unearthed, and temporarily correlated. Facts carefully established by experiment and observation, and gathered together in the form of carefully made general statements become verbal expressions of the laws of nature. These generalizations so reached are the real treasures of science; they constitute the solid stones of which the temple of science is built; and it is through these that science serves mankind in the broadest and highest sense of the word. It is clearly very essential that the teacher should at all times distinguish very carefully between what is hypothesis and what is fact. The latter once carefully established stands firm and unchangeable, while the theory is only useful in so far as it enables one to group known facts together and to discover new truths. As soon as a theory becomes inadequate

to do this, its period of usefulness is over and its doom is sealed. The pathway of the progress of science is strewn with defunct theories and hypotheses. The spectacle of the birth, growth and death of scientific theories often appalls the less thoroughly versed, for they see in it, as they fancy, the instability of science. Much of this misconception would soon disappear if teachers would always insist that their pupils distinguish at all times between facts and opinions or assumptions, and never for a moment elevate the latter in their minds to the dignity of the former. In this attitude of mind toward fact and theory the teacher of science must ever lead by strong force of example, if he would truly succeed in his vocation, and especially if he would seek during his spare hours to add something of value to the sum total of human knowledge. The one who becomes so imbued with a theory that he raises it in his mind to the dignity of a fact is sure to fall into serious errors; for while hypotheses frequently aid the investigator by stimulating inquiry and by suggesting new relations and new ways of doing things, they also very often by their equally strong hints that such and such things are impossible stifle inquiry along certain lines, prevent new discoveries from being made, and so become a real bar to true progress. However, the investigator who ever bears in mind the difference betwen facts and theories is not in the least worried by the continual coming and going of the latter; and the teacher of science who leads his pupils to distinguish between established truths and hypotheses need have no apprehension that he has misled his pupils by acquainting them with a theory that soon after has to be entirely discarded. Yet it is true that it is best not to bring to the notice of students—at least of students of high school grade—scientific theories that have not a broad foundation of facts to stand upon, or theories of which it is evident at the time of instruction that their period of usefulness is practically over.

There is practically no one theory of chemistry that has attracted more attention in the last fifteen years than the theory of electrolytic dissociation proposed by Arrhenius in 1887. Though far from universally accepted, it still has many ardent adherents. This theory is so well known that it is entirely unnecessary to give its purport or its history here. It will be recalled that the

hypothesis is based primarily upon the claims of Arrhenius that the molecular conductivity of many solutions (that had been measured at the time of the promulgation of the theory) increases with the dilution; that substances which when dissolved conduct electricity also have "abnormally" low molecular weights in such solutions when tested by freezing- or boiling-point methods; and that the so-called degree of dissociation may be calculated from the electrical conductivity or the results of the molecular weight determinations. In his original paper Arrhenius stated that the phenomena of electrolysis, when viewed in the light of thermodynamics, require the assumption of free ions as was pointed out by Clausius, and that the heats of neutralization of acids and bases in dilute solutions, and the various physical properties of salt solutions, which are well known to be, in general, additive in character, support the electrolytic dissociation hypothesis. Through the latter it was sought to gain for the van't Hoff theory of solutions a general application, and at the same time to bring into correlation facts that had hitherto been entirely isolated. Inasmuch as the commonly used aqueous solutions of acids, bases and salts are electrolytes, practically all the well known chemical reactions of neutralization, precipitation by double decomposition, etc., many of which occur instantaneously, were soon viewed as taking place between the so-called free ions. Books explaining chemical changes and changes of solubility on the ionic basis were soon published; of these Ostwald's *Scientific Foundations of Analytical Chemistry* was the most prominent one, from which ideas were taken, modified, elaborated and incorporated into more elementary texts. The claim was even made that the chemistry of atoms and molecules has given place to the chemistry of ions, and that chemical affinity is a back number.

In the face of the enthusiasm shown by adherents of the dissociation theory and the voluminous material they have published, it is no wonder that teachers are often made to feel that they are entirely behind the times, unless they teach their chemistry with the theory of electrolytic dissociation as the back bone of it, and in general explain the chemical, physical and physiological behavior of solutions from the standpoint of the dissociation theory. But the teacher of the secondary school was not alone

in this, university professors and other investigators of note in physics, chemistry and physiology were looked at askance and even pitied because they could not see what Lothar Meyer called "das wilde Heer der Ionen," and follow them in their gambols.

There are now at hand abundant well established facts that show that the theory of electrolytic dissociation is entirely inadequate, in reality untenable. To rehearse all these here in detail is entirely impossible; they have been fully presented from time to time in a series of articles in the *Journal of Physical Chemistry,* and to these the reader must be referred. In summary, it has been shown that instantaneous chemical reactions, solubility changes, and coloration changes (comparable in every way with those that take place in the common aqueous electrolytic solutions) occur in solutions that are most excellent insulators. On the other hand, the presence of electrolytic conductivity has been found to be by no means necessarily accompanied by chemical action. (Compare the recent article by Kahlenberg and Schlundt on the behavior of solutions in which liquid hydrocyanic acid is the solvent, *Jour. Phys. Chem.,* Oct., 1902.) Thus chemical action takes place quite independent of electrolytic conduction; and, again, the explanation, that, for example, the chlorine in such compounds as chloroform can not be precipitated as silver chloride because the chlorine is not in the ionic state, inasmuch as chloroform is not an electrolyte, is clearly no longer valid. Of this the reader will be convinced by referring to my article in the January number of the *Jour. Phys. Chem.,* 1902. Furthermore, so-called abnormally low freezing-points or abnormally high boiling-points of solutions are by no means always accompanied by electrolytic conduction; while normal freezing-points, normal boiling-points or even abnormally high freezing-points and abnormally low boiling-points are frequently exhibited by solutions that are electrolytes. Again the molecular conductivity does not always increase with the dilution. These statements are true of aqueous as well as of non-aqueous solutions. It is therefore clear that the dissociation theory is no longer tenable. It has become untenable because further investigations have furnished facts that are chemical, physical and physiological in character showing how very inadequate the theory is. With the downfall of the Arrhenius hypothesis, the

original difficulty with the van't Hoff theory of solutions recurs. The latter hypothesis is based upon the analogy between gases and solutions, and is practically inseparably connected with the Arrhenius theory. No doubt these theories have done much toward stimulating research in chemistry and physiology and due credit should be given them on this account. The theory of solutions has, however, directed attention exclusively to dilute solutions. It has thus stood in the way of the study of more concentrated solutions and so has in reality unquestionably been a drawback to true progress toward a thorough understanding of the very important subject of solutions. Similarly the Arrhenius theory has directed particular attention to the phenomena in dilute solutions. The *facts* known at present are sufficient to warrant the expression of the opinion that for a true conception of the nature of solutions and of electrolytic processes it is extremely unfortunate that work should have been directed thus almost exclusively toward dilute solutions.

The act of solution itself is undoubtedly caused by a mutual attraction of solvent and solute, which attraction depends upon the individual nature of the substances under consideration. This mutual attraction is very closely allied to, if not essentially identical with, what is commonly called chemical affinity. This attraction is the so-called osmotic pressure. In the careful study of the act of solution, and of the physical, chemical and physiological properties of solutions nothing becomes more evident than that chemical affinity between solvent and solute really determines all these phenomena. Chemical affinity then should be brought to the forefront in the study of solutions rather than relegated to the background. As for the electrolytic conductivity of solutions, no one can tell whether a given solution will conduct electricity or not without actually trying it. The Arrhenius theory claims to be able to make such predictions, but the facts show that it is entirely unable to do so. We have at present no adequate mechanical explanation of the process of electrolytic conduction; and this is not astonishing, for we also have no such explanation of the conduction of electricity in a wire. It is quite probable that we shall eventually find that these two phenomena are much more intimately related to each other than they seem to be at present.

Moreover, as Fitzgerald said so well in his celebrated Helmholtz memorial lecture, it is not to be charged against any one that he is unable to explain all the phenomena of the universe. The general course that should be pursued in the further study of solutions, I have indicated in the *Jour. Phys. Chem.*, June, 1901.

In being gradually outgrown by the multiplication of facts that are not in harmony with it, the theory of electrolytic dissociation has simply followed the natural course that all scientific hypotheses, founded upon too narrow a basis of induction, must eventually take. Nor need it cause a pang of regret or a sigh to see a worn-out theory go, even though a new one is not at once at hand to supplant it. The older and the more perfect a science is, the fewer theories it has. At any rate, investigations bringing facts that undeceive us as to the real adequacy of a theory, always represent a true step forward; they are always to be welcomed.

The teacher who has not hitherto seen fit to bring the theory of electrolytic dissociation to the notice of his pupils, certainly has no good reason for doing so now, for he can not be classed as being behind the times if he omits mentioning the theory. On the other hand, he who has given his instruction entirely or in part by means of the theory should study with care the new facts that are at hand; should bring these before his pupils, who will not be slow to recognize that the theory is unable to stand in face of the facts. Above all, let the pupils repeat the experiments and then draw the conclusions that follow directly from them. Thus they will learn to love and conserve the truth though theories may fall, and they will at least in a measure experience what the great Scheele did, when he said: "es ist ja nur die Wahrheit, welche wir wissen wollen, und welche Freude bereitet es nicht sie erforscht zu haben."

THE COCOANUT—ITS COMPOSITION AND GERMINATION.

BY J. E. KIRKWOOD.

Instructor in Botany, Syracuse University.

It is not strange that some of our most common articles of commerce should yield some very interesting facts when properly investigated, and the cocoanut is one of these. Probably every one knows the general characteristics of this fruit, and some may know its value as a food and the particular nature of its food content. Some recent investigations,* however, have shown that such knowledge as we have is in the form of rather fragmentary information contributed from various sources. Inasmuch as the cocoanut is not a native of these latitudes and is cultivated only in conservatories, some of the very interesting features of its early growth are also entirely unknown to many. The investigations, the results of which are given in the paper just cited, were undertaken with a view to determining the nature and quantity of the food content of the fresh nut and the manner and extent of its utility to the young seedling.

It is a matter of common observation that the meat of the cocoanut contains much fat. In the manufacture of the commercial cocoa-oil this is obtained by pressure or by other mechanical means. In the fibrous residue from this process there is still some of the fat left, hence it is evident that one cannot by this means come by a knowledge of the exact percentage of fat in the meat. If, however, the tissue is ground to a pulp and then placed in some solvent of fat, preferably ether or benzine, by proper manipulation even the last trace of the fat may be removed, and, knowing the weight of the raw material and the extracted fat, after evaporation of the solvent, its percentage may be obtained by a simple calculation. By this means we obtained from the fresh meat of the nut 37.29 per cent of substance soluble in ether, which may, of course, contain traces of other bodies besides fat.

(*) Kirkwood & Gies, Chemical Studies of the Cocoanut with some Notes on the Changes during Germination. *Bull. Tor. Bot. Club.* 29:321-359. June, 1902.

The solid residue of the tissue, which had been thus treated, was freed from ether by evaporation, and placed in a ten per cent solution of common salt and allowed to stand, with occasional agitation, for a day or two; the proteid bodies, at least the most of them, were thus removed. The salt solution, after filtering, was placed in a bag of vegetable parchment and hung in running water. As proteid bodies not affected by digestive agents are indiffusible, they remained in the parchment vessels after all the salt had diffused out, which took sometimes several days. The contents of the vessel were then removed and the proteid which had been partly precipitated by removal of the salt was separated by filtration and the filtrate heated and treated with chemicals to remove whatever proteid remained. Details of the process need not be described here, as the methods are those given in some of the laboratory manuals in botany.† This treatment yielded 4.08 per cent of albuminous substance.

As to the presence of sugars and other soluble carbohydrates, it was found that the fresh meat of the nut or endosperm contains about 7.9 per cent. Both cane sugar and grape sugar are present, but the exact quantity of carbohydrate is probably not expressed in the figure given above, as they were not especially investigated and the expression of the approximate quantity was obtained by subtraction. Other non-nitrogenous substance is probably included in this as well. The fresh meat contains 46.31 per cent water and 52.69 per cent solid matter. The solids besides including the substances already named contain 1.03 per cent of mineral and 3.39 per cent of fibrous matter. Among the mineral substances present are found usually silica, iron, aluminum, calcium, magnesium, potassium, phosphorus and sulphur. The percentage figures given above were the averages of many different determinations made both upon fresh nuts directly imported from Jamaica and upon nuts from the market in New York city. It will be seen from the figures given that the cocoanut is a very nutritious article of diet. Nearly fifty per cent of the weight of the fresh meat is food in the ordinary sense of the word, that is, proteid, carbohydrate and fat. The milk of the nut contains 4.77 per

(†) MacDougal, *Practical Text Book of Plant Physiology*. Ch. IX. Longmans, Green & Co. 1901.

cent of solids, of which 0.56 per cent is mineral substance, and 4.21 per cent is organic (carbohydrate, fat, etc.). Only traces of proteids are present; fat may be seen floating about in small globules if a drop of the milk is examined under a lens. Sugar forms the principal part of the solid matter. The fresh milk is slightly acid, due to the presence of acid phosphate. Both alkali and earthy phosphate are present, and the latter can be precipitated, in part at least, on boiling. Evaporation of the milk to a small bulk by heat produces a dark colored, molasses-like substance from which cane sugar crystallizes on cooling.

As the cocoanut comes to our markets it is deprived of its husk. This husk is of a coarse fibrous structure and covers the nut so thickly that in its original form the fruit is broadly oval, the nut occupying an eccentric position with the "eyes" directed toward the stem end of the fruit. In its natural habitat the cocoa palm grows abundantly near the water and as the fruit falls from the tree it often floats about until it comes to rest in some shallow place and there germinates. The husk not only makes the fruit lighter, but probably serves under any condition by virtue of its absorptive quality to keep the seed more moist and so facilitate germination. Many of the nuts imported in the husk for our work were germinated by keeping them about half covered with earth, saturated and at tropical temperature.

The germ of the nut is to be found under one of the so-called "eyes" at the end. The longitudinal ridges separate the hard coat into three parts, which evidently were once the three parts of an ovary which bore three seeds, one for each division or carpel. The seeds have become reduced to one, which fills all the space within the hard shell which is in reality a part of the ovary wall. The fertile carpel may be detected as the one lying in the largest angle formed by the divergent ridges at the end of the nut.

When the nuts are kept under proper cultural conditions for about three months the first signs of germination will be evident by the appearance of the shoot through the husk above and the roots below. By this time the germ, which is in its resting condition cylindrical and lying perpendicular to the surface of the nut, has elongated and pushed its inner end into the cavity of the nut and the other end outward. The outer end develops the

stem and roots. The inner end expands into an oval body which ultimately, after about ten months, fills the entire cavity. This expanded inner end is the cotyledon which functions as an absorbing organ. Wherever this cotyledon comes in contact with the meat of the nut it softens, dissolves and finally absorbs it. The surface of the organ is covered with villiform structures and corrugations which give it much the appearance of a stomach turned inside out, and as far as function goes that is just what it amounts to. Wherever the endosperm has not been attacked by the cotyledon it remains as palatable as ever and apparently unaltered.

This process of digestion proceeds by means of ferments or enzymes. In any digestive organ, animal or vegetable, the transformation of insoluble and indiffusible proteid, carbohydrate, or fat into a soluble and diffusible form is accomplished by means of enzymes. It is often possible to separate these ferments from the organs or cells which produce them and to demonstrate their activity upon foods when thus separated. For example, the active principle of yeast may be separated from the yeast cell; the starch-digesting diastase found in many seeds has long been in use for various purposes. But enzymes are often found mixed with the food material in resting cells where the special digestive organ either is or is not present, and it becomes active only when conditions are right for germination. A common means of extracting the enzyme is to cover the finely divided tissue with water and allow it to stand for several hours. The water is then filtered and the enzyme precipitated by adding several volumes of alcohol. The precipitate may be separated by any convenient means such as filtering and dried. It is active, however, only when in solution. The presence of an enzyme may be detected by watching its action on starch paste, fibrin, fat or substance taken from the tissue in which it is found. In the cocoanut the cotyledon shows a very active enzymatic action. The study of this particular seed in its germination is instructive, both from the morphological and physiological point of view. The transformation of the fat of the meat into starch takes place, and this is readily evident to the investigator, although there is no starch in the meat, but during germination there is much of it to be seen in the cotyledon. Proper tests on microscopic sections demonstrate the presence

of fat in the outermost layer of cells of the cotyledon and the absence of starch there; likewise the presence of starch in the inner tissues and the absence of fat.

The food reserve in the cocoanut lasts about a year after germination has begun. During this time the plant gets much of its nutriment from the soil and the air. The proportion of water diminishes from the cotyledon to the tips of the leaves and there is a corresponding increase in the amount of solid matter. The substance of the cotyledon, the stem and the roots, contains much more mineral matter than is to be found in the endosperm and the leaves. The problems of nutrition in this plant which are suggested by these observations have not yet been attacked, but they will no doubt afford some very interesting facts at some future date.

THE EUROPEAN EDIBLE SNAIL.

BY M. A. BIGELOW.

Department of Biology, Teachers' College, Columbia University, New York.

The value of the European edible snail (*Helix pomatia*) for observation on the living animal, as well as for anatomical study, deserves to be more widely known to teachers of biology and nature study than appears to be the case at present. I know of no animal which is at once so available, so easily kept living in the laboratory until needed for class work, and so interesting to pupils of all grades. These snails are now regularly imported from France and Germany, and may be found in the provision markets of the large cities during the cooler months, *i.e.*, from about October 15 to April 1. In New York they may be ordered from C. Perceval, dealer in table delicacies and fine provisions, 100 Sixth avenue. They usually cost about $1.25 per hundred. The Brooklyn Biological Supply Co., 333 Halsey street, Brooklyn, supplies them in small quantities. Less than two dozen in a package may be sent by mail.

These snails are brought from Europe in the dormant or winter condition, the aperture of the shell being sealed by the temporary plate (epiphragm) of calcified mucus. In this condition they may be packed, shipped, and stored for months in dry sawdust or "excelsior." The snails may be purchased in autumn and the stock kept in some *cool, dry* place until they are wanted for class study, perhaps in late spring. When active snails are needed, it is only necessary to put them in a warm, wet place on grassy sod, moss, sand, or sawdust; under the influence of the moisture the epiphragm soon softens and the head and foot emerge from the shell. The emergence may be hastened by first removing the epiphragm.

The active snails may be kept so for months in a simple vivarium which consists of a shallow box or bucket covered with coarse wire netting and having the bottom covered with grassy sod or coarse sand. I prefer the sand because it may be washed in running water occasionally, which is desirable in case the vivarium is kept in the school room. The snails may be fed with lettuce, cabbage and other vegetables.

Perhaps the most convenient way to handle the living snail in the class-room is to allow it to crawl on a plate of glass to which the foot soon firmly adheres. All external parts and movements are then easily seen from any desired point of view. Lettuce leaves may be placed near the mouth and the process of feeding observed through the glass; and in the same way the remarkable muscular movements of the foot may be seen. If the snails are sluggish when wanted for class study, stimulate them by repeated dipping into lukewarm water.

These snails are best killed for anatomical study by drowning in water which has been boiled to expel the air and kept tightly covered until cooled. Then put the snails into the water, cover tightly, and after about thirty hours they will be found more or less stupefied in an expanded condition. Select those which are quite stupified and place them one by one in water heated as hot as the hand will bear, quickly smooth out wrinkles in the foot, press upon the bases of tentacles to extend them, and having arranged the parts as natural as possible, drop the animal into 5 per cent formaline. With a little practice 80 per cent of the snails can be killed and hardened in a very life-like condition of expansion. After

hardening for a few days in the formaline, the visceral mass of some individuals may be easily twisted out of the shell, but usually the columellar muscle clings so firmly that it is necessary to chip the shell with forceps in order to remove it.

A METHOD FOR COLLECTING AMOEBAE.

BY S. O. MAST.

Department of Biol. Science, Hope College, Holland, Mich.

Amoeba is an animal of such vital importance in the study of biology and so difficult to collect in numbers large enough for class use, that, I trust, anything that may be said to facilitate their collection will be of interest to readers of SCHOOL SCIENCE.

Until this year in collecting amoeba, we simply scraped the surface ooze from the bottom of a spring hole near our college laboratory, with a small net of coarse cotton, and put it into pint fruit jars. In working with such collections, it was noticed that as soon as the ooze settled amoebæ were found on or near its surface; consequently it was thought that if taller vessels of the same capacity were used so as to make the surface of the ooze in them comparatively smaller, the animals would be found in proportionally larger numbers. In order to test this idea, ooze was collected in pint jars and after it had thoroughly settled, the surface of the ooze in the jars was lifted with a large pipette and put into test tubes and again allowed to settle. In this way amoebæ were concentrated to such an extent that as many as fourteen were found in a single drop taken from the surface of the ooze in the test tubes, while usually several drops taken from the surface of the ooze in the jars had to be examined to find a single animal.

If the animals are not to be used at once, it is well to put a few fibers of spirogyra or some other aquatic plant into each test tube. By so doing amoebæ were kept in good condition for over a week.

TUBERCULOUS SPUTUM IN PUBLIC STREETS.

BY W. H. MANWARING.

Johns Hopkins Medical School, Special Lecturer in Hygiene, Eastern Illinois State Normal School.

Dr. H. E. Annett has recently published the preliminary results of an experimental inquiry he is making as to the prevalence of the germs of tuberculosis in sputum taken from the public sidewalks of Liverpool.* His results are so striking that they cannot fail to impress even the most elementary student of public hygiene.

His paper opens with a brief review of the most important facts bearing on the hygiene of tuberculosis. He calls attention to the controversy now going on as to the relation between the human and the bovine forms of the disease, and says that, although authorities are as yet not agreed as to what this relation is or what the danger from tuberculous cattle may be, they all agree with KOCH that "human sputum is the main source of human tuberculosis."

Infection from such sputum takes place, he says, most readily in over-crowded and ill-ventilated dwellings, workshops, and rooms, but may come from its inhalation in public places in the form or dust, or from its introduction into our homes on boots, shoes, and skirts. His inquiry is to determine how great these latter dangers really are.

Tubercle bacilli outside the human body are subjected to many conditions unfavorable to the life of micro-organisms. Among these are drying and the action of sunlight and of putrefactive agents. Experiments show, however, that these germs are very hardy. They withstand drying for over six months and resist putrefaction and sunlight for long periods of time. There is even evidence that under favorable conditions they may actually multiply in sputum outside the human body.†

* The Thompson Yates Laboratories Reports (Liverpool), Vol. IV (1902), p. 359

† Sternberg, Manual of Bacteriology, p. 381.

The demonstration of tubercle bacilli in consumptive sputum is a comparatively simple matter. It is based on their staining characteristic. Their chemical structure is such that, by proper methods, they can be colored bright red, while other bacteria likely to be present in human sputum, are stained blue.

This is the usual test for these germs, but is not an absolute proof of their presence, because there are a few rare bacteria, e. g., the bacillus of leprosy, that give the same reaction. The strict demonstration is obtained, therefore, only by inoculation methods. A guinea pig inoculated with tuberculous material will develop tuberculosis and ultimately die of the disease. A microscopic study of properly stained sections of its tissues will then show typical lesions swarming with tubercle bacilli.

Dr. Annett collected 108 specimens of sputum from the sidewalks of Liverpool, mucous, muco-purulent and purulent accumulations being taken indiscriminately, only the most liquid ones being neglected. From each specimen he made two smears on cover glasses, and with portions of each he inoculated two guinea pigs.

The results of his study up to the date of publication are as follows:

1. A microscopic examination of the stained cover glass preparation showed probable tubercle bacilli in three of the specimens.

2. In five of the inoculation experiments, both animals died of general tuberculosis.

Five of the 108 specimens, therefore, contained virulent tubercle bacilli, though in two of them not in sufficient numbers to be readily found microscopically. Practically 5 per cent, one-twentieth, of the mucous, muco-purulent and purulent expectoration on the sidewalks of Liverpool are, therefore, tuberculous, and, consequently, a menace to public health.

The number of such sputa daily deposited on public sidewalks can be inferred from the fact that, in a slow walk of one hour along the principal streets of that city, Dr. Annett counted 183 such accumulations. When we take into account the rapidity with which sputum dries, is ground into the dirt, or swept up by trailing garments and thus rendered invisible, we realize that

this number gives but a faint idea of the extent to which objectionable expectoration is going on, and, consequently, of the extent to which pedestrians are subjected to infection by tubercle bacilli.

Dr. Annett believes that the dangers from such expectorations can be overcome by the following means:

1. By educating the public to an understanding of the dangers from such sputum.

2. By passing laws regulating expectoration in public places.

3. By daily washing and cleansing the sidewalks of the principal streets.

He commends the efforts already made in the United States to overcome these dangers and quotes the laws relative to the matter now in force in Baltimore, New York and other of our eastern cities. He closes his article with an appeal for similar legislation in England.

Those, however, who have watched the almost futile attempts of legislation to overcome this evil in our larger cities, cannot escape the conviction that to his first and third means only can society look for relief. And of these, education is the more important, as it is the necessary foundation for all other means.

This education should include a first hand knowledge of the main facts bearing on the hygiene of tuberculosis,* an understanding of the predisposing factors of the disease,† and a familiarity with the results of the modern methods of treating it.‡ It can be given to advantage only in the public schools. To it, and to the public school teacher in particular, must society look for help in banishing the "great white death." As Dr. Knopf so strikingly says, "to combat consumption successfully requires the combined action of a wise government, well trained physicians, *and an intelligent people.*"§

Are the public school teachers doing all they can to create this wide-spread intelligence on which the government and the physician must build?

---

* Abbott, Hygiene of Transmissible Diseases, p. 112.

† Bergey, Principles of Hygiene, p. 25.

‡ Hiller, Tuberculosis, Its Nature, Prevention and Treatment. (Cassell & Co., London and New York, 1900), Chapter VII, p. 157.

§ Knopf, Tuberculosis, a Disease of the Masses and How to Combat It. (The International Prize Essay of 1900; M. Fierstack, Publisher, N. Y.), p. 86.

Metrology.*

SYSTEM IN METRIC WEIGHTS AND MEASURES.

Now that people are making some use of metric weights and measures in this country it is of interest to notice what is the essential characteristic upon which the superiority of the system depends. The advantage of relations between different kinds of measure is not generally appreciated among the people of the United States because of their lack of past experience of such simplicity; as paintings are not appreciated by the blind, or music by the deaf. To make our people recognize the advantage of simple relations, one course is to point out what little relationship is still to be found connected with our old weights and measures and is therefore comparatively easily understood; for many of them are surviving fragments of what were originally systematic arrangements.

It has been the usual plan to have coinage related to weight. There used to be in England a silver coinage of which 240 pence made a money pound, and there used to be a pound weight and a penny-weight as heavy as the corresponding silver coins. Even after various changes had been made, if silver, or any other material, was worth a fraction of a penny per pennyweight, it was worth the same fraction of a pound sterling per pound troy. The correspondence of the names made it easier to keep the association in mind. The relation in question dated from a thousand years ago. The monetary reckoning was established by Charlemagne and spread over the principal countries of Europe and America. The weight was derived from the Roman Empire of 2,000 years ago, where they used the Roman numerals, such as we see on old clock dials, tombstones, etc., so that subdivision into twelfths was not open to the objection that it is here now. The twelfth of the pound was called ounce, from the Latin word, *uncia*, meaning originally one-twelfth part of the monetary unit, but having its meaning extended to one-twelfth of any unit.

* Communications for the Department of Metrology should be sent to Rufus P. Williams, North Cambridge, Mass.

It was used for a twelfth of the unit of liquid measure and for a twelfth of the unit of land area; and from its meaning the twelfth of the foot we have our word *inch* also. This was systematic to some extent. In countries that inherited the Roman civilization something near the Roman inch and foot, and for medicinal purposes something near the Roman weight, continued, with numberless minor variations in value, down to about a century ago, along with 12 pence in the shilling; but these things have been abandoned almost everywhere.

For another illustration of lost connections, the apothecaries in Great Britain and the United States used to have measures and weights corresponding, thus:

A fluidounce, containing 8 fluidrachms, each of 60 minims, or drops	and	an ounce (Troy), of 8 drachms, each weighing 60 grains.

These names and ratios gave obvious simplicity, which had its value even when the measures had been made to hold weights a little different from those indicated. They emphatically called attention to the relation between capacity measure and weight of water contained, which has been the ideal of the most widely separated times and places. The old saying was "A pint's a pound the world around." For a succinct statement as to ancient connections in England, the following passage may be quoted from the celebrated *Lectures on Natural Philosophy* (1807) by Dr. Thomas Young, who was subsequently one of the Commissioners of Weights and Measures. Referring to Phil. Trans. 1740, p. 457, he said:

"Mr. Barlow supposes that the ton measure of water contained originally 32 cubic feet, and weighed 2,000 pounds, which was also called a ton weight, the gallon being somewhat smaller than it is at present, and the cubic foot weighing exactly 1,000 ounces, or 62½ pounds. A quarter of wheat weighed about a quarter of a ton, and a bushel as much as a cubic foot of water. A chaldron of coals was also considered as equivalent to a ton, although it now weighs nearly half as much more."

The notable points are that simplicity of relation was a primary consideration, but has not survived in the anomalous old English capacity measures and weights of the United States. In

Great Britain those units of capacity were swept away and on the recommendation of Dr. Young and his fellow commissioners the single series of imperial capacity measures was introduced in 1826, having a tolerable connection with water; and the weights and measures of the British Pharmacopoeia were correspondingly altered, so that in Great Britain

A fluidounce held an ounce (Av.) of water.
A pint held 1¼ pounds (Av.) of water.
A quart held 2½ pounds (Av.) of water.
A gallon held 10 pounds (Av) of water.
A peck held 20 pounds (Av.) of water.
A bushel held 80 pounds (Av.) of water.
A quarter held 640 pounds (Av.) of water, etc.

The statement of specific gravity is by reference to water, another illustration of the common consent to its use as a standard.

In surveying also there was a relationship in the old measure attributed to the ingenuity of Edmund Gunter; there was a simple relation between length and area. Gunter's chain, which has been to considerable extent superseded by other units, had 100 links, and was 1/10 of the furlong, while the square chain was 1/10 of an acre. The decimal subdivision was an important feature of this land measure.

The measurement of time and of arcs and angles exhibits a survival of a little bit of an ancient comprehensive sexagesimal system of arithmetic. Everybody knows that sixty seconds make a minute, and sixty minutes make a degree or hour. The correspondence between the measurement of arc and the measurement of time is unmistakable, though not very close; since fifteen degrees correspond to an hour and fifteen minutes of arc to a minute of time, fifteen seconds of arc to a second of time. The system from which this originated extended very much further; the second was divided into sixty parts and successive subdivision by 60 was continued; whereas now complication is introduced by dividing seconds decimally. Other multiples of 60 were also used in Asia.

(To be continued.)

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

PHYSIOLOGY.

Hygiene as a factor in education is discussed by Mr. Geo. A. Soper, in the November number of the *Educational Review*. Hygiene is not thoroughly taught in many schools, the cause of temperance being confused with that of hygiene. Teachers who are especially prepared receive no suitable recognition for their services. Facilities for higher training in hygiene in the United States are thought to be inadequate. Only in Vermont is provision made for training health officers. Sanitary instruction in medical schools, even, is not accorded a very important place; yet the outlook for better instruction is good and the future looks more hopeful.

Is color-blindness preventable? is discussed by Alida S. Williams in the *Educational Review* for November. After giving the current views, many having reference to imperfections or lesions in the eye or transmitting parts, and percentages—4.5 per cent in men and only 0.4 per cent to 0.6 per cent in women—the writer agrees with a minority of observers that the fault is in interpretation and therefore psychic and curable in future generations. The writer thinks "that disuse is the true explanation and cause of color blindness, which is indicated, if not fully proved, by the fact that little boys show no traces of this weakness when they are taught as their sisters are." This statement is borne out by an examination of 580 children in a primary school who have been well taught in colors and only one was color blind. L M.

This fine appeal quoted in *American Medicine* from the headworker of the College Settlement of Philadelphia, is worth quoting again:

"To say 'congested quarters, poor water-supply, surface drainage and privy-wells, the street as playground, the malodorous heat of our nights,' is one thing; to *feel* the murderous quality of these conditions is quite another thing. To aid in changing for the better the condition and the people who suffer and die from them—none the less because they are often ignorant of and indifferent to, or sometimes even the cause of, their own loss and destruction—this is yet a third thing, but the greatest, excelling knowledge and feeling, as charity surpasses faith and hope."

The Dietetic and Hygienic Gazette for November reviews the investigations of Duclaux on the influence of intestinal bacteria on nutrition. Many of the bacteria of the alimentary canal of man seem to be

symbiotic. Duclaux experimented with chicks kept absolutely sterile from the time of hatching. The chicks lost weight steadily, the greatest recorded loss being 32 per cent of the initial weight, and all died within one month. During this time the control chicks gained as much as 117 per cent in weight. The sterile birds were constantly eating while losing flesh and strength, and excreting abundantly. Their condition changed almost immediately, however, to one of natural health and growth as soon as a little of the excrement of the control birds was added to their food, thus supplying them with the normal flora of the alimentary canal.

Cigarette Smoking Among Juveniles.—A number of school boards in England have undertaken a crusade against cigarette smoking among young boys. The Plymouth board has issued circulars to the parents of children under their charge, calling attention to the growth of the habit and its pernicious influences, and at Leeds the board has sought the assistance of eminent medical authorities in an effort to curtail the habit. Other school boards have submitted reports, commenting on the mental, moral and physical deterioration of the cigarette smoker, as observed in the schools under their charge.—*American Medicine.*

The city of Providence sends to the teachers in the public schools a circular on the teaching of cleanliness, of which the following is a portion, as reported by Dr. Charles V. Chapin in *Medical News*:

TEACH THE CHILDREN

Not to spit; it is rarely necessary. To spit on a slate ,floor, or sidewalk, is an abomination.

Not to put the fingers into the mouth.

Not to pick the nose.

Not to wet the finger with saliva in turning the leaves of books.

Not to put pencils into the mouth or moisten them with the lips.

Not to put money into the mouth.

Not to put pins into the mouth.

Not to put anything into the mouth except food and drink.

Not to swap apple cores, candy, chewing gum, half-eaten food, whistles or bean blowers, or anything that is habitually put in the mouth.

Teach the children to wash the hands and face often. See that they keep them clean. If a child is coming down with a communicable disease, it is reasonable to believe that there is less chance of infecting persons and things if the hands and face are washed clean and not daubed with the secretions of the nose and mouth.

Teach the children to turn the face aside when coughing or sneezing if they are facing another person.

Children should be taught that their bodies are their own private possessions, that personal cleanliness is a duty, that the mouth is for eating and speaking, and should not be used as a pocket, and the lips should not take the place of fingers. F. W. R.

Book Reviews.

A Laboratory Outline of General Chemistry. By ALEXANDER SMITH, B. Sc., PH. D., Associate Professor of Chemistry in the University of Chicago. Second Edition, revised. 13x19 cm., and ix+107 pages. The University of Chicago Press, 1902. $0.75.

This manual is of particular interest to teachers in secondary schools as showing what the author of "The Teaching of Chemistry" considers the proper course in the laboratory for students in general chemistry. The emphasis laid on quantitative work and the thorough-going use of the ionization theory merit special mention. Teachers of chemistry in secondary schools will find much that is suggestive and helpful in the book.

C. E. I.

Guide to Preparation Work in Inorganic Chemistry for Students of Chemistry and Pharmacy. By DR. REINHART BLOCHMANN. Translated by JAS. LEWIS HOWE. 18x14 cms. 73 pages. Department of Chemistry, Washington and Lee University, Lexington, Va., 1902. 60 cents.

The scope, arrangement, and detailed directions of this book adapt it for effective use in colleges and in high schools. Teachers who cannot use it with classes will profit by personal performance of the experiments. Over half of the preparations could be done with success by a high school class. The illustrations are excellent, and the typography attractive—features not always found in German-American textbooks.

LYMAN C. NEWELL.

Outlines for Field Studies of Some Common Plants. By C. H. ROBISON, A. M., Oak Park (Ill.) High School. 13x20 cm. 39 pages, paper covers.

According to the prefatory note of the author this is a guide by which first year students of the high school can make independent observations on wild plants during the fall months. In connection with this study "Coulter's Plant Relations" is to be used as a reading book; conclusions are to be brought out in recitations.

In the hands of the author himself or any skilled teacher this scheme would be successfully carried out; but directions that could be used by any teacher or with no teacher, would be more valuable. The outlines consisting of twelve main topics which include the leaf, stem, fruit, seed and a general study of trees develop nearly all phases of the life history of a common plant. Some subjects, such as "leaf arrangement" and " light relation," are treated very much in detail,

while other topics, as pollination, are merely mentioned. After the complete study of the leaf arrangement to obtain light, there is no experiment to show what the reason for it all is. The facts are not well connected; there is no definite aim and unity is lacking. As the author states, he has left the conclusions to be developed in class. But would it not be better to have the pupil develop his own conclusions first, and then discuss them in class with the teacher?

Though several plants are mentioned under each head, a beginner would probably be unfamiliar with nearly all of them. There are also terms that would be unfamiliar to the amateur. The study of the flower is placed almost at the close, an unfavorable arrangement if the work is done in autumn.

In the primary essential of science training—to require independent observation and thought—with few exceptions, the outlines are excellent. The questions are clearly and simply framed; the student has no doubt as to what he is to do, and at the same time no clue to the answer desired. In addition to the training the student would gain a considerable knowledge of the plants, their habits, and many interesting facts concerning their structure. Besides this the outlines are stimulating to future work in the same line.

Detroit Central High School. BERNICE L. HAUG.

Animal Activities. By NATHANIEL S. FRENCH, Teacher of Zoölogy in the Roxbury (Mass.) High School. 13×19×2.5 cm., and xxi+262 pages. Longmans, Green & Co., New York, 1902. $1.10.

This "first book in zoölogy" aims "to interest and guide pupils in the study of living animals. It is essentially a "natural history, like the old-time books, placing particular emphasis upon general external structure, life histories, habits, ecological relations and general classification. Some attention is given to internal structures and to the general processes of nutrition in various animals. The order of study begins with insects, and after the arthropods it follows the natural order from Protozoa to mammals.

A serious fault of many parts of the book is that too little stress is placed upon practical work as the only basis for sound zoölogical teaching. This is especially true along morphological and physiological lines, the "natural history" phase being well represented by practical work. There is too much emphasis and dependence placed upon descriptions of structures and processes which are in no way involved in the laboratory study outlined in the book; and, moreover, these descriptions are often inadequate, apparently assuming preliminary knowledge on the part of the pupils. These criticisms apply especially to the descriptions of minute structure, internal organs and physiological processes; for example, the term "cell" is introduced without description,

figures or any suggestions for a laboratory demonstration of cells in typical tissues. An extreme case of this emphasis upon mere descriptions is found in the chapter on protozoa and sponges. In order not "to burden this course with the details of microscopic manipulation we must content ourselves with verbal descriptions," and after studying the activites of amoeba in several pages of words and diagrams, a microscope "may" be used to examine Paramecium! Likewise, sponges "are not recommended for the laboratory," but four pages of descriptions and diagrams of sections from a complex sponge, remove all difficulties which the actual objects will surely bring to young beginners!

It is as a "natural history" that "Animal Activities" is commendable. Along this line the practical work is well outlined and there is a large amount of popular and important information about common animals. It is both a good guide and a reader for the study of the very interesting phases of animal life, which are usually included in "natural history" as it is now presented in many high schools.

M. A. Bigelow.

Reports of Meetings.

THE PHYSICS CLUB OF NEW YORK.

The nineteenth meeting of the club, held on Oct. 25, took the form of a visit to the Sawyer-Mann Electric Company's works on 23rd street, New York. The various steps in the manufacture of an electric lamp were shown from the preparation of the flanged tubes which hold the platinum wires to the final wrapping and storing of the lamp preparatory to shipment for use. The processes which interested the members of the Physics Club most were the exhausting and sealing of the lamp, the final preparation of the film by coating it with a hydro-carbon compound, the testing the lamp for its candle power. After two hours had been spent in visiting the factory, the club witnessed a demonstration of the Nernst lamp, given by Mr. H. N. Potter, special engineer in the Westinghouse Laboratory. Mr. Potter also gave the members a demonstration of the Hewitt lamp, which, in some respects, was the most interesting part of the morning program. This meeting is the first of its kind that the club has held and it was considered very instructive. After lunch the meeting adjourned.

Reported by R. H. Cornish.

NEW YORK CHEMISTRY TEACHERS' CLUB.

The third meeting of the club was held at the Hotel Albert, New York, on the evening of October 30, 1902. The topic of the evening was: Are the exercises in the syllabus of the College Entrance Examination Board the best that could be devised to develop the conceptions of combining weights and formulas?

Papers were read: R. W. Fuller, DeWitt Clinton High School; W. J. Hancock, Erasmus Hall High School; C. M. Allen, Pratt Institute, and a general discussion followed.

M. D. SOHON.

THE COURSES IN CHEMISTRY AND PHYSICS IN THE NEW YORK HIGH SCHOOLS.

During the past school year City Superintendent Maxwell appointed committees of teachers to prepare syllabuses of courses in the various high school studies. The Committee on Physics and Chemistry recommended the adoption of the syllabus of the College Entrance Examination Board.

At the October meeting of the New York High School Teachers' Association, M. D. Sohon, chairman of the Committee on Physics and Chemistry, made the following statement:

The Committee on Physics and Chemistry, recommending to the city superintendent the adoption of the syllabus of the College Entrance Examination Board, has kept in view the fact that, to graduate from the high schools of New York, the pupil must hereafter pass these examinations, and, as so large a proportion of these pupils desire to enter higher institutions, these requirements must represent the minimum, to be considered. Further, as the position of these subjects in the school curriculum has been changed, the committee did not consider it advisable to suggest any modification until it had received a fair trial in its new position in the school.

The course in physics has been developed by the experience of many years in various schools; it is preëminently a laboratory course for individual instruction, and aims to teach the pupil carefulness, accuracy and judgment.

The instruction is: (*a*) Laboratory exercises (35); (*b*) demonstration or lecture, recitation; (*c*) textbook study. The first term (half year) is to be devoted to the study of Mechanics and Sound, the second term (half year) to Heat, Light, Electricity and Magnetism.

The exercises are fairly distributed, no one branch being slighted or unduly emphasized, and in number the exercises are sufficient to permit a large amount of freedom in selection and method of presentation.

Hitherto in Manhattan and Bronx this course has occupied five hours per week in the fourth year; in some schools of the city this

amount of time has been exceeded. The new course of study introduces it into the *third year* (five hours per week, one of these to be unprepared to pupils who have not in the previous year studied science.

This fact places us in a serious position. The course, as outlined, has been subjected to repeated experiences and criticisms, and at present is, I believe, the course most desirable to be pursued in our school, but it must be borne in mind that we are about to attempt to accomplish in practically *four hours per week of the third year* what we have hitherto regarded as demanding *five hours per week of the fourth year.*

How can this be done? The only method that seems practical is to insist on the subdivision of our usual classes into such units as can be successfully handled.

Compared with the syllabus in physics, the chemistry syllabus is for equal grades of pupils somewhat more difficult. This course is also experimental and is based on the same plan as the physics syllabus.

The course, as outlined, is very broad, touches most of the common and important materials, processes, general chemical phenomena, and their application in daily life and commerce.

This syllabus is more recent and has not yet been subjected to such extended criticism as has the physics syllabus, and while an excellent course is outlined, or may be developed from it, in its present form it can scarcely be considered as well developed or as well balanced as is the physics, and much more is left to the discretion of the teacher.

It seems as if the study of the non-metallic elements is unduly emphasized and the metals slighted. The facility with which the non-metals lend themselves to laboratory demonstration accounts for this apparent partiality, and it must be corrected by the teacher. (See examination *questions.*) More recent theory as to the nature of solution is touched upon and formula worship relegated to a subordinate position (expressly stated in syllabus, but apparently overlooked by some of the examiners).

In both the courses the teacher has a very large amount of freedom. The work outlined is of a high grade and is of such character as not only to meet his college requirements, but affords a systematic practical training and furnishes information which will be of future value, and, if a fair standard be maintained by the C. E. E. Board, I believe these courses in physics and chemistry will prove all that is necessary or desirable in our high schools.

NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

The third meeting of the association for the year 1902 was held at Erasmus Hall High School, Brooklyn, May 16.

Mr. J. E. Peabody of the Peter Cooper High School was the first

speaker, his subject being "Induction in Biological Courses." There are five steps in induction. First, observation of facts; second, comparison of facts; third, induction. We might stop here, but we need to go farther in order to see if more facts conform. Therefore, fourth, deductive reasoning and consequently, fifth, modification. As an illustration, suppose we have studied endogenous and exogenous stems and have noted the veinage of their leaves. We might conclude that all stems having parallel veined leaves would be endogenous, which is not the case. Hence the need of further observation of facts, deduction and modification.

Mr. M. A. Bigelow of the Teachers' College gave an outline of Mr. T. E. Lloyd's paper on "The Framing in Method of Thought Received in the Study of Biology", Mr. Lloyd not being able to be present. An abstract of the paper is as follows:

Educators generally accept the doctrine that work in science must be so presented as to give training in the inductive method of thought (the scientific method in the broad sense, as used by Karl Pearson) with due regard to the importance of the doctrine of probabilities. To use the more common expressions, students must "observe facts" and "draw correct inferences."

As a matter of fact this method as applied to biological teaching is not generally used. In common practice we ILLUSTRATE an important principle or law; we usually do not generalize from a sufficient number of carefully ascertained facts.

This is not in itself a fault. It is merely a practical necessity. Time and other limitations forbid even an approach to the strictly inductive method.

The teacher must be careful to distinguish between the actual result of an experiment or observation and the general law of which such is an illustration. It is only in this way that proper appreciation of the value of evidence and of degree of probability will characterize the results of science teaching.

Mr. Bigelow then spoke on the subject of "Developing Intellectual Power." The paper discussed the value of biology in the intellectual life of a liberally educated man whose interests touch upon the fields of cosmic philosophy, sociology, psychology, ethics, and religion. The relation between biological facts and generalizations and these phases of human knowledge was reviewed in outline. Finally the suggestion was made that even an elementary course of biology may give the student at least a viewpoint which in later year may be important in giving the proper perspective to philosophic studies. Such a result does not necessitate that the biological work should digress in order to point out its bearing upon other fields of knowledge.

The next speaker, Mr. A. J. Grout of the Boys' High School, Brook-

lyn, gave an interesting talk on the "Value of Biology as an Additional Interest in Life." Very few boys make use of their physics or chemistry in after life. Few subjects are able to be used. But knowledge of and an interest in living things should afford a source of inexhaustible pleasure and satisfaction. Few people can take an intelligent interest in nature. People in the city waste their time on things unworthy of them and people in the country are unable to get any pleasure from the multitudinous phases of nature with which they are surrounded.

We should so teach biology that it will afford a never-ending interest in life.

Mr. H. A. Kelley of the Ethical School of Culture, Manhattan, spoke on the subject: "In How Far are the Present Courses in Biology Adapted to the Need of the Adolescent?"

We should not attempt to do college work in the high school. The instructor may be an excellent investigator, but a poor teacher. Three things are to be considered in the preparation of a teacher. First, appreciation of the subject matter. Second, knowledge of the child's state of development. Third, the power to transmit. We must recognize the various periods in a child's life and present the subject in accordance with the child's needs and his state of development.

The reading of these papers was followed by a general discussion of all of them.

Reported by ARTHUR E. HUNT, Temporary Secretary.

The fourth meeting of the current year was held in the Board Rooms, Board of Education Building, 59th street and Park avenue, at 8:15 p. m., November 7th, with President H. R. Linville in the chair.

An unusually large number of members and friends, including several principals and superintendents, had gathered to hear what was a most interesting and instructive evenings' discussion on the following topic: "What Understanding is Possible Between High Schools and Colleges with Regard to College Entrance Work in Biology?"

It was expected that Dr. E. B. Wilson, of Columbia University, would be present to give his views on the zoölogical aspect, but owing to his illness and enforced absence, Dr. Linville opened the discussion with an account of the general work attempted by the course in biology as now given in the high schools of Greater New York. Half of each year being devoted to botany and zoölogy, with a treatment of the subject from the physiological aspect. The immaturity of the student makes necessary a course of external morphology with reference to the internal morphology only through dissection made by the teacher and given with the view of explaining the physiological processes that take place. Stimulation of the student by natural history and drill then

give the main educational values to the course. The future student in chemistry or physics is thus started with the laboratory idea. The addition of the fourth year elective in biology will, it is believed, do much toward giving the desired college entrance course.

Dr. Linville then introduced the speaker of the evening, Prof. Wm. F. Ganong of Smith College. He spoke in part as follows: "An understanding is possible between high schools and colleges with reference to a college entrance option, for it already exists and several students have taken advantage of it at Smith. The course must be a full year in either zoölogy or botany. Out of 13 points of the Smith entrance examinations, biology counts as 4 points.

"The college must accept a good educational course in the high school. It must be in a general way as equivalent to their introductory course and for this reason should be a full year of either zoölogy or botany. A half-year course cannot well be utilized by the college. Biology must be made of as much value as the other sciences. Botany and zoölogy are not isolated subjects, but part of a general educational plan from the lowest to the highest grades. An actual distaste to this kind of work among students is often due to the discontinuity of their science work.

The characteristic of a good course in botany should be one which will give the student a good idea of the science as it stands at present. Anatomy, physiology, ecology and taxonomy should all have their place in the course. In a general way one-third of the year might be given respectively to anatomy, physiology and form-relationships."

The teacher was referred to the third report of the committee appointed by the society for plant morphology and physiology printed in the May issue of this journal, and copies were distributed to all present.

An interesting discussion followed Dr. Ganong's address, participated in by Prof. Lloyd of the Teachers' College, Dr. McDougal of the New York Botanical Gardens and Messrs. Peabody, Kelley, Goodwin and others of the city schools. The question was raised by Drs. Lloyd and Kelley as to the interest of the child in biological science in the fourth year of the high school. Some doubt was expressed as to the child's attitude toward the subject after the interest of the first year had worn off. After a general discussion the meeting adjourned until December 5th.

A day or two after the meeting Dr. E. B. Wilson kindly offered to send the writer his views on the subject discussed at the meeting. The following letter expresses briefly the points under discussion.

My Dear Mr. Hunter:

My views regarding biology in high schools and its relation to biology in college are somewhat as follows.

I think we should distinguish very clearly between biology as a

subject for college entrance and biology as a study pursued for its own sake in the high school.

As regards biology as a subject for entrance, I have always been of the opinion that elementary chemistry and physics form a better preparation for such courses in biology as we try to give than zoölogy, botany, or combination courses in biology in the schools; and I would much prefer to teach students well prepared in chemistry and physics, and with no knowledge of biology, than those who have had a year of biology without adequate elementary training in the other sciences. For these reasons, while I am most heartily in favor of biological instruction in the schools, as complete and extended as time will allow, I am not very favorable toward their recognition as entrance subjects. If, however, they are offered as entrance subjects, I am decidedly of the opinion that for this purpose a whole year's course in botany or in zoölogy is preferable to a mixed year of general biology. My own experience has demonstrated to me the fact that general biology in the form in which I try to teach it can only be properly appreciated by students of rather mature minds, and for this reason I have always taken the position that the course in general biology should not be taken before the junior year, as is our practice at Columbia. To teach general biology of this kind to high school students is of doubtful utility and obviously quite out of the question in the earlier years of the school course. I therefore think than an entrance requirement in zoölogy should include (1) an acquaintance with the essential facts of physiology in the higher animals, with especial reference to human physiology, and (2) a course in zoölogy proper, with especial reference to comparative anatomy and to ecology. It appears to me that the more children can be taught of general natural history of the old fashioned kind the better, including such things as the habits and distribution of animals, the external features of their development and metamorphoses (tadpoles, insect larvæ, and the like) and something too of elementary systematic zoölogy, so that they may recognize our commonest animals, though I appreciate the difficulties of doing this in a city school. These things may well come in the earlier years of school life. The study of elementary comparative anatomy should be deferred until the later years.

In the case of students who are taking only a high school course, I think it might be practicable to give an effective course in general biology of a simple kind, including in this the general principles of comparative physiology, the relations of plants and animals, the work of bacteria, and even some of the problems of evolution; were I giving such courses I should treat them very differently from those that I give to college juniors.

Very truly,

EDMUND. B. WILSON.

Reported by G. W. HUNTER, JR., Secretary.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The thirty-fourth meeting was held at the East Boston (Mass.) High School on Saturday, November 8, 1902. The members were the guests of Mr. W. H. Godfrey, teacher of physics and chemistry in this school. A portion of the morning was devoted to an inspection of the laboratories. The building is new and the equipment thoroughly modern and servicable. At the business meeting it was voted to extend the limit of active members to 75, and to provide for unlimited associate membership.

The committee on apparatus, through its chairman, Mr. C. H. Andrews, reported on the Nernst lamp. The following is a brief abstract:

"The lamp is an invention of Professor Nernst, and although it has only quite recently been perfected so as to be placed on the market, its essential principles were made public some years ago. The patent rights for the United States have been purchased by George Westinghouse and large sums of money have been expended by him in bringing the lamp to its present state of perfection.

"The light emanates from a filament or glower about three-fourths of an inch in length, of a composition of a rare earth which, at the ordinary temperature, is of such high resistance as to be practically a non-conductor of the electric current, but which when sufficiently heated becomes a conductor and becomes very highly incandescent, glowing with an intense white light.

"It is necessary, to light the lamp, to first heat the glower. This Professor Nernst accomplished by a match or a small alcohol lamp; but Mr. Westinghouse has perfected an arrangement by which the heating is brought about by two small heaters, so called, which consist of coils of platinum wire imbedded in clay and placed on either side of the glower. When the electric current is turned on, it first flows through the heaters, which raise the temperature of the glower until it becomes a conductor, when it suddenly becomes incandescent; while an automatic cut-off throws the heaters out of the circuit.

"The chief advantage of the lamp lies in its great economy. A single glower will give 50 C. P. with a ground glass globe and 75 C. P. without a globe, with an expenditure of only 83 watts, or about one watt per C. P., whereas an ordinary lamp requires from 3 to 4 watts per C. P., according to its age. The light is also very white and if properly shaded, very agreeable to the eye. The life of the glower is about 800 hours, and it may be easily replaced at a cost of twenty-five cents. At present, owing to some electrolytic action, the lamp can be used only on alternating currents, but it is hoped that this difficulty may be soon overcome. The light, coming as it does, from a very small area, casts a sharp shadow, and it would seem that those users of a stereopticon, who are looking for a substitute for the arc lamp, which is more or less troublesome to

keep in adjustment, will find the Nernst lamp a welcome addition to their projection outfit. On 220 volt circuits three glowers may be used in a single lamp, giving a light of about 200 C. P."

The committee on magazine literature, Mr. W. F. Rice, chairman, presented the following list of articles on physics, which appeared from June to October, 1902.

MECHANICS.

Mechanical Engineering of an Electric Railway. Howard P. Quick. *Engineering Magazine*, July.

Measurement and Calculation. R. S. Woodward. *Science*, June 20.

Recent Progress in American Bridge Construction. Henry S. Jacoby. *Science*, July 4.

LIGHT.

Lighting of Railway Trains in Europe. H. Guerin. *Engineering Magazine*, October.

Photographing Sound Waves. *Scientific American*, Vol. LXXVII, 34.

New Theory of Light and Colors. Sir Isaac Newton. *Popular Science Monthly*, September. Reprint of letter to Royal Society, February 6, 1672.

ELECTRICITY.

Elementary Principles of the Electro-Magnet. *Science and Industry*, Vol. VII, 317, 346, 421 and 482.

Enclosed Arc Light. *Science and Industry*, Vol. VII, 404 and 457.

Roentgen Ray Burns. *Scientific American*, Vol. LXXVI, 342.

Transformers. R. B. Williamson. *Science and Industry*, Vol. VII, 359.

The Ions of Electrolysis. A. Crum Brown. *Science*, June 6.

Curious Electrical Forms. Anabel Parker. *Century*, July.

Radio-Activity. A New Property of Matter. R. K. Duncan. *Harper's Monthly*, August.

Newest Definitions of Electricity. Carl Snyder. *Harper's Monthly*, October.

High Speed Electric Interurban Railways. Geo. H. Gibson. *Engineering Magazine*, September.

Physical Limits of Electric Power Transmission. Alton D. Adams. *Engineering Magazine*, October.

HEAT.

Science of Steam Making. J. C. Parker. *Science and Industry*, Vol. VII, 240.

Steam Turbines. William Brulingham. *Science and Industry*, Vol. VII, 351.

The Heat Balance. R. T. Strohm. *Science and Industry*, Vol. VII, 311.

The Modern Engine. *Science and Industry*, Vol. VII, 315.

MISCELLANEOUS.

Diamonds by Electric Furnace. *Scientific American,* Vol. LXXVII, 141.

Further Development of Niagara's Power. *Scientific American,* Vol. LXXVII, 234.

United States and Metric Systems. *Scientific American,* Vol. LXXVI, 343.

The Laws of Nature. S. P. Langley. *Science,* June 13.

Peter Guthrie Tait. C. K. Edmunds. *Popular Science Monthly,* June.

Mr. George W. Earle, vice president of the association, delivered the annual address of that officer. The following is a summary:

"The State Teachers' Association of New York, in answer to a circular letter sent to the leading business and professional men of New York city received over four hundred replies. These men were unanimous in stating that the schools in fitting boys for useful employment, 'ought to lay great stress upon character building, upon the training of the morals and manners, and inculcate an ability to *follow instructions*.

"In helping to train and develop pupils along these lines, would not the science teacher be a most powerful help? What could assist in 'character building' more than hard and honest work in the laboratory at some difficult quantitative experiment, where the pupil must rely upon his own efforts and depend for success upon truthful observation, accurate readings, and a *strict following out of directions?* Does not every laboratory teacher feel, from his own experience, that no subject taught in the public schools has greater influence in training pupils to thoughtfulness, observation, reliability and to the importance of *obeying orders,* than the study of the sciences?

"Are the teachers of science doing all the good in this direction to the pupils in the high schools that it is possible for them to do? They are not. They do not come into contact with as many pupils as they ought.

"In general, the number taking science in the high schools is very small. There are usually only two science teachers in a school. These two seem satisfied with small divisions. The number of pupils taking physics has a tendency to become less and less each year.

"If the sciences are as important as science teachers claim, and as leading educators claim, this is to be regretted. The laboratory teacher is not that strong factor in helping train boys and girls for a useful life that he ought to be.

"In every large school there are many teachers of mathematics, of history. Why not also many teachers of physics, chemistry and biology; and all pupils be required to take a certain amount of these sciences?

"Boys and girls would not only be benefited by the discipline resulting from such studies, but their lives would be made happier and capable of greater usefulness."

Mr. J. W. Hutchins reviewed Smith and Hall's "The Teaching of Chemistry and Physics" favorably.

After lunch, the members listened to an address by Professor H. W. Morse of Harvard University on "Electricity Direct from Coal." The address was largely historical and speculative. He said the main problem was to get carbon and oxygen to unite so that their union would give a current of electricity. After discussing several attempts to construct such a cell, he said, in conclusion: "No such cell has been successful up to the present. We have brought the dynamo and the storage battery to perfection. No one can say what the next ten or fifteen years may bring out of the investigation concerning these cells."

Reported by LYMAN C. NEWELL.

Correspondence.

EDITOR SCHOOL SCIENCE:

The article in the December number on the "Examination of Baking Powders" suggests "to other teachers the possibility of similar experiments." Perhaps some work done along this line by advanced students at the Phillips Exeter Academy may be of interest.

Three brands of so-called cleansing "potashes" on the market were analyzed qualitatively and were found to be mixtures of from two to four compounds each. The interesting fact was brought out that the trade names were not always safe indicators of the compounds actually present. Quantitative experiments, devised partly by the students themselves, showed that the ingredients were present in proportions varying from 2 to 90 per cent for those ingredients present in smallest and largest proportions, respectively.

To get percentages for comparison it is necessary to use the same can for all determinations, for it was found that different cans of the same brand varied from 5 to 10 per cent on some ingredients where the experimental error was probably within one per cent. These mixtures were very satisfactory to work with on account of the absence of acid radicals that cause considerable trouble in quantitative methods.

WILHELM SEGERBLOM.

School Science

VOL. II] FEBRUARY, 1903. [No. 8

PLANT PHYSIOLOGY FOR THE HIGH SCHOOL.

BY W. F. GANONG.

Professor of Botany in Smith College.

The present paper is intended as an introduction to a series of articles on plant physiology for the High School, which I hope to contribute to SCHOOL SCIENCE, not in consecutive numbers, but from time to time as they are completed. I propose to take up each of the topics in plant physiology which are so fundamental that they should be treated in a high school course, and I shall omit all others. Under each topic I shall endeavor to give a clear exposition of its importance and general bearings, with the principal facts about it; a description of the best apparatus and methods known to me for demonstration, for individual student work and for makeshift, with practical directions for the use of each, and warnings for the avoidance of common errors; a discussion of the correct physics and chemistry of each subject, and of the theories to account for the phenomena; a treatment of good pedagogical methods of handling the subject; and a summary of its bearings upon the other phenomena of plant and animal life, especially upon the structures and adaptations of plants.

The thoughtful reader will at once ask how I am to decide upon the topics to be selected for such treatment, or in other words, how in the face of much probable difference of opinion upon

the subject I am to decide which topics are fundamental in an elementary course. In answer I would say that I shall take those topics which have been recommended in the most authoritative document which at present exists upon the subject—the Standard Course formulated by the Committee of the Society for Plant Morphology and Physiology and published in this journal in May, 1902. The physiological topics as there recommended, and as they will be treated in this series (though not necessarily in this order) are the following, those requiring experiments being in italics:

Role of water in the plant; *absorption (osmosis), path of transfer, transpiration, turgidity and its mechanical value, plasmolysis.*

Photosynthesis; *Dependence of starch formation upon chlorophyll, light and carbon dioxide; evolution of oxygen,* observation of starch grains.

Respiration; *necessity for oxygen in growth, evolution of carbon dioxide.*

Digestion; *Digestion of starch with diastase,* and its role in translocation of foods.

Irritability; *Geotropism, heliotropism* and *hydrotropism;* nature of stimulus and response.

Growth; *localization in higher plants; amount in germinating seeds and stems; relationships to temperature.*

Fertilization; sexual and vegetative reproduction.

I. INTRODUCTION.

There are many differences between the older and the newer botanical instruction, but the greatest of these is the presence in the newer of much plant physiology. Whether one views the modern textbooks, or the courses in the more advanced institutions, or recent educational discussions—it is everywhere the same, a strong emphasis upon plant physiology as an integral part of every truly scientific elementary course in botany.

That the emphasis upon this phase of the science is no passing whim, but a permanent addition to scientific education,

there is every evidence. Its growth has been gradual and sound, and it has won recognition as an indispensable foundation for an understanding not only of plant structure and adaptations, but also of the simpler processes of animal physiology, as illuminating and pleasing knowledge, and as a peculiarly valuable intellectual discipline, one going far towards aiding to elevate botany to as high an educational rank as any subject possesses. It is now safe to say that every progressive and well-informed high school teacher either already has introduced a fair proportion of the subject into his instruction, or else is preparing to do so.

To secure its full educational value, however, there is one great prerequisite, namely that it shall be taught in the truly scientific inductive spirit from actual personal observation and logical experiment. This phase of the subject has been treated by Professor Barnes in the December (1902) number of this journal, and I am so fully in agreement with him, that his article might well form a part of the introduction to the present series. As to the solution of the practical difficulties of teaching this subject to large classes, I have offered some suggestions, based upon a considerable personal experience, in the February (1902) number of this journal. By far the best way is to have all experiments performed by each student individually, but as that is generally impossible in high schools, a fair substitute consists in making each student a participant in the experimenting, holding him responsible for as full an understanding and exposition of each experiment as if it were actually carried out by himself individually. As the aforementioned articles are, no doubt, generally accessible to my present readers, I need not here repeat their recommendations.

The understanding of plant physiology is by no means easy, but this is precisely one of its chief educational values. Moreover, the teacher should by no means attempt to select its easiest, but its most important parts. It is far better that the pupil should attack those questions which the nature of the subject points out as most fundamental and illuminating, and do the best he can with them, than that he should concern himself with matters of lesser importance even though these are easier to study and more open to simple experiment. I do not believe at all that this, or any

other subject, should be used for the primary purpose of giving training in observation, etc. (those parts of it being selected which approve themselves as best for this purpose), but I hold that each subject should be studied primarily for its own sake, and with the attention directed first of all to its true proportions and its distinctive methods. This not only puts the study upon a much higher plane, but the training in observation, reasoning, etc., incidentally gained is much greater than if these are made a primary object in themselves. After all, these things in education are a means to an end, not an end in themselves. While I believe that hard or easy, the important phases of any subject should be courageously attacked, it certainly is a very happy circumstance that none of the fundamental topics of plant physiology are beyond the grasp of the average high school student if properly led by a competent teacher. In our high specialization of methods, and our extension of the elective system, we are too prone to regard the student's inclination as the test of the value of a subject to him, losing sight of the value of effort in education and of its necessity in a training for achievement.

The proportional amount of attention that plant physiology should receive in an elementary course in botany is correctly represented, I believe, in the Standard High School Course formulated by a Committee of the Society for Plant Morphology and Physiology, and published in the May (1902) number of this journal, to which the reader is recommended to refer. As to the proper, or ideal, place for a course in botany involving this amount of physiology, I believe it should come as late in the high school course (or as early in the college course) as possible. It is very desirable that it shall be preceded by some instruction in chemistry and physics, though this is not indispensable, especially if the pupils have been taught, as they should be, the elemental facts and processes of nature through nature study in the lower schools.

Until very recently plant physiology could not be taught generally in elementary courses for three reasons; properly trained teachers were not obtainable; there were no books suitable as guides for either teachers or pupils; and the needful apparatus was costly, and cumbersome to manipulate. All of these difficulties have been in large part overcome. Many of our good colleges are

sending out graduates well trained to teach this subject; several good books, adapted especially to the conditions prevailing in our schools, have been published; and apparatus has been simplified and cheapened to an extent allowing its purchase and use by all.

The books useful as guides in elementary plant physiology are the following.* Most of the recent elementary textbooks contain directions upon simple experimenting, and these directions are particularly practical in Professor Barnes' *Plant Life*. There are two books devoted specifically to simple experimenting in plant physiology, MacDougal's *Elementary Plant Physiology*, and my own *Laboratory Course in Plant Physiology*. Neither of these is a textbook of physiology, for which one should turn to MacDougal's larger work—*Practical Text Book of Plant Physiology*, which is a combined laboratory guide and textbook. The best modern reading book on the subject is J. Reynolds Green's *Introduction to Vegetable Physiology*, but Noll's *Physiology* in Strasburger's Textbook is also good. A new work by Peirce, just announced as ready for publication, is of this kind. Of more elaborate books of laboratory directions the standard is Moor's translation of Detmer's well-known *Practical Plant Physiology*, an admirable work, more extensive than the elementary teacher is likely to use but invaluable for reference; and of much value, too, is Darwin and Acton's *Practical Physiology of Plants*. Of reference works the great standard is Ewart's translation of Pfeffer's work, entitled *The Physiology of Plants*, a new and invaluable handbook of physiological fact by the greatest living master of the subject. It is too exhaustive and too technical for the use of elementary students, but indispensable to the progressive teacher. There are other useful works, especially including the *Lectures* of Sachs and of Vines (now out of print) which may be found described in the bibliography of my book above mentioned, but those here cited are the most important to our present subject.

The publishers and prices of the works cited in this paragraph are:—Barnes, Plant Life, Holt & Co., $1.12; Ganong, Laboratory Course, Holt & Co., $1.00: MacDougal, Elementary Plant Physiology, Longmans, Green & Co. $1.20 and his Practical Text Book, Longmans, Green & Co., $3.00; Green's Introduction, Churchill (London) 10s. 6d.; Strasburger's Text Book, Macmillan, $4.50; Peirce's work is to be published by Holt & Co.; Detmer-Moor, Practical Plant Physiology, Macmillan Co., $3.00; Darwin and Acton, Practical Physiology, Cambridge, England, 4s. 6d.: Pfeffer-Ewart, Physiology, Clarendon Press, Oxford, Vol. I, 28sh. (Vol. II not yet ready.)

The apparatus described in the works by MacDougal and by myself has been so simplified that most of the necessary materials and appliances may be bought from any Supply Company, or manufacturerd from materials easily obtainable. Curiously enough the direction taken in this country in the simplification of appliances has been almost entirely towards the utilization of apparatus and mechanisms already developed for other purposes, and there has been but little new apparatus specifically designed for work in plant physiology manufactured and offered for sale,* nor has any firm in this country yet made a specialty of supplying materials needed for the subject. Not much more is to be expected from the adaptation of existing appliances, and it is desirable now to develop moderately accurate and moderately-priced apparatus for this express purpose. I have myself designed a number of pieces of such apparatus, and have prepared lists of materials needed in elementary plant physiology; and negotiations are in progress which will enable me, I trust, to announce, before this series of articles has proceeded very far, that specially made apparatus and all needful minor supplies may be purchased at reasonable cost from a responsible firm in this country. Apparatus may be classified into four groups: First, there is that for *investigation,* which must be the most accurate that can be made; this is usually costly and difficult of manipulation, and hence of only secondary interest to the teacher of elementary courses. Second, there is that for *demonstration,* by which the fundamental processes may be clearly, logically and conveniently demonstrated to large classes; this is of primary importance where facilities are not available for individual student work, and in any case, a collection of it has much value. Third, there is that for *individual student work,* necessarily much simpler than the preceding, but capable of being made to give fairly accurate results; this is the most valuable of all where facilities for individual work are available, and that which the teacher should endeavor to obtain as far as possible. Fourth, there is *make-shift apparatus,* constructed from easily accessible and inexpensive materials, which everybody can afford and obtain; it is

* Practically the only exception is the several excellent pieces made and sold by Professor J. C. Arthur, Purdue University, Lafayette, Indiana.

valuable if it gives the correct *kinds* of results, even though these be quantitatively inaccurate.

There is another question connected with apparatus which will here occur to the reader, namely, whether this experimental work can be carried on without a greenhouse. Certainly the greenhouse is desirable, and, for all advanced work, indispensable; but for the experiments here in question it is not necessary, though some form of Wardian case, adapted to keep the plants to some extent under greenhouse conditions, is needed*.

Other practical points in connection with the subject will be treated in their appropriate places later in the series.

HIGH SCHOOL BOTANY.

BY V. A. SUYDAM.

Supervising Principal, Public Schools, Ripon, Wis.

Botany is the unsettled study in our high schools today, and is likely to remain so until it is taught from the standpoint of the practical in education. Educators do not seem able to agree as to what should constitute the course in botany, and largely for the reason that they have not recognized the needs of the schools, but have been trying to bring them above themselves into the realm of the technical and exact before they are ready for it. One thing has been agreed to and that is that the old form of botany teaching was nothing more than "book larnin', which is true enough. This kind of teaching has been discarded as worthless, and the clamor has been to study plants and not books. This is all well enough, but along with the change has come a condition which is little better than the old. Simply to study plants is not enough. There should be a purpose in that study. Particular plants should be studied because they are worth knowing about, and particular facts should be studied about these plants because they have a bearing upon our lives. "Learning those

* I have discussed the subject of Wardian Cases and their cost in my "Teaching Botanist," pages 82-85.

things in nature that are best worth knowing, to the end of doing those things that make life most worth living" is the purpose in nature study as expressed by Clifton F. Hodge, and it applies as well to botany.

Botany today, in most high schools, is nearly as unsatisfactory as formerly. Many textbooks have been written, and many courses mapped out, and still our pupils are wasting time in studying botany. The fault has been with nearly all of these courses that botany has been treated from the standpoint of the college and university, and not from the standpoint of the high school. They have not taken into account the mental stock in trade of the high school pupil, nor have they recognized the fact that the high school is the "people's college," and that the botany taught here should be for the pupil who does not go to college, as well as for the pupil who does go to college. As now taught it is too scientific and too exact for the needs of the high school. Says L. H. Bailey: "Education should train persons to live, rather than to be scientists." Hence we would learn that botany should be made more practical, nearer the life and needs of the child of high school age. What the public demands, and rightly so, is high school botany in the high school, and not the ridiculous attempt at teaching college botany in the high school, and that, in most cases, by teachers unfit for the work.

In most other studies we have well graded courses leading gradually from the simple to the complex, from the known to the unknown, from the concrete to the abstract, from the general to the particular, from that which is a part of the child's every day life to life in foreign lands, and in all of these there is an attempt made to keep close to the human element, and to that which has a place in the complete development of the child. In most studies we adhere to the law that the mind must struggle with problems which are within its range. The child should have that which is fitted to his mind at a particular stage of mental development just as truly as he should have a suit of clothes to fit his body at a particular stage in his physical development. Apart from the fitting of the subject to the child, there is the natural sequence to the matter of the subject which must be recognized in planning any course. There are always topics which

are elementary and should be learned first, and topics which are advanced and should be learned later. To reverse this order is a positive harm, or, to say the least, is a waste of time.

In the case of botany much of this is disregarded. There appears to be very little attempt at gradation. From the very first day the pupil, upon taking up high school botany, is plunged into a study of the minute parts of plants. In some cases he is started with a compound microscope placed before him. He is given sections to study which have been prepared for him. In the very nature of the case he cannot understand where they came from or what they really represent. He has not a wide enough acquaintance with plants, has not a sufficient botanical setting to comprehend what he is attempting. Even if he has acquired a wide acquaintance with plants before coming to the study of botany in the high school his mind is too immature for this exact and technical work.

Botany in the high school must of necessity be elementary. However, this does not mean that it must be made easier, but that the work must be confined to topics which are within the range of the pupil's understanding. To attempt to teach botany from the standpoint of the university in the high school satisfies neither the demands of the great majority who never go beyond the high school, nor the few who go to college. In the first instance, the pupil who finishes his education with the high school has no use for the knowledge acquired by the study of the minute structure of plants, or the advanced problems in the subject, except so far as they are within his mental range and at the same time have some human value. What he needs in the way of knowledge and discipline to be of any practical value to him is knowledge and discipline which will enable him to recognize the various trees, shrubs, and herbs in his locality, and to know of their value or harm to mankind; knowledge which will tell him of the habits of these plants, where they live, how they live, what conditions are beneficial and what are not; knowledge relating to the economic value of plants, what plants are of economic value, how they grow and where they grow best, what soils they are best suited to, what their enemies are and how these enemies are recognized by man and subdued. In a word, there is a vast field of botany to be studied

which will put the student into close relationship with his surroundings, and which can be studied with very inexpensive apparatus. This is a large enough field to occupy the entire time given to botany in any high school. It will take the pupil into the woods and fields to get his knowledge, as far as possible, first hand, rather than confining him to a study of prepared specimens in the laboratory, of the habits and habitats of which he has and can get very little or no knowledge. One might as well study about a city without knowing where it is located or what its relationship to other geographic knowledge is, or the details of events in a certain period of history without knowing its date or where it fits into the framework of history.

(*Concluded in March.*)

VARIOUS LOW-TEMPERATURE RESEARCHES.*

BY JAMES DEWAR.

We may now summarize some of the results which have been attained by low-temperature studies. In the first place, the great majority of chemical interactions are entirely suspended, but an element of such exceptional powers of combination as fluorine is still active at the temperature of liquid air. Whether solid fluorine and liquid hydrogen would interact, no one can at present say. Bodies naturally become denser, but even a highly expansive substance like ice does not appear to reach the density of water at the lowest temperature. This is confirmatory of the view that the particles of matter under such conditions are not packed in the closest possible way. The force of cohesion is greatly increased at low temperatures, as is shown by the additional stress required to rupture metallic wires. This fact is of interest in connection with two conflicting theories of matter. Lord Kelvin's view is that the forces that hold together the particles of bodies may be accounted for without assuming any other agency than gravitation or any other law than the

* Part of the address of the President of the British Association for the Advancement of Science delivered in Belfast, Ireland, September, 1902.

Newtonian. An opposite view is that the phenomena of the aggregation of molecules depend upon the molecular vibration as a physical cause. Hence, at the zero of absolute temperature, this vibrating energy being in complete abeyance, the phenomena of cohesion should cease to exist, and matter generally be reduced to an incoherent heap of cosmic dust. This second view receives no support from experiment.

The photographic action of light is diminished at the temperature of liquid air to about twenty per cent. of its ordinary efficiency, and at the still lower temperature of liquid hydrogen only about ten per cent of the original sensitivity remains. At the temperature of liquid air or liquid hydrogen a large range of organic bodies and many inorganic ones acquire under exposure to violet light the property of phosphorescence. Such bodies glow faintly so long as they are kept cold, but become exceedingly brilliant during the period when the temperature is rising. Even solid air is a phosphorescent body. All the alkaline earth sulphides which phosphoresce brilliantly at the ordinary temperature lose this property when cooled, to be revived on heating; but such bodies in the first instance may be stimulated through the absorption of light at the lowest temperatures. Radio-active bodies, on the other hand, like radium, which are naturally self-luminous, maintain this luminosity unimpaired at the very lowest temperatures, and are still capable of inducing phosphorescence in bodies like the platino-cyanides. Some crystals become for a time self-luminous when cooled in liquid air or hydrogen, owing to the induced electric stimulation causing discharges between the crystal molecules. This phenomenon is very pronounced with nitrate of uranium and some platino-cyanides.

In conjunction with Professor Fleming, a long series of experiments was made on the electric and magnetic properties of bodies at low temperatures. The subjects that have been under investigation may be classified as follows: "The Thermo-Electric powers of Pure Metals;" "The Magnetic Properties of Iron and Steel;" "Dielectric Constants;" "The Magnetic and Electric Constants of Liquid Oxygen;" "Magnetic Susceptibility."

The investigations have shown that electric conductivity in pure metals varies almost inversely as the absolute temperature

down to *minus* 200 degrees, but that this law is greatly affected by the presence of the most minute amount of impurity. Hence the results amount to a proof that electric resistance in pure metals is closely dependent upon the molecular or atomic motion which gives rise to temperature, and that the process by which the energy constituting what is called an electric current is dissipated essentially depends upon non-homogeneity of structure and upon the absolute temperature of the material. It might be inferred that at the zero of absolute temperature resistance would vanish altogether, and all pure metals become perfect conductors of electricity. This conclusion, however, has been rendered very doubtful by subsequent observations made at still lower temperatures, which appear to point to an ultimate finite resistance. Thus the temperature at which copper was assumed to have no resistance was *minus* 223 degrees, but that metal has been cooled to *minus* 253 degrees without getting rid of all resistance. The reduction in resistance of some of the metals at the boiling point of hydrogen is very remarkable. Thus copper has only one per cent, gold and platinum three per cent, and silver four per cent of the resistance they possessed at zero C., but iron still retains twelve per cent of its initial resistance. In the case of alloys and impure metals, cold brings about a much smaller decrease in resistivity, and in the case of carbon and insulators like gutta-percha, glass, ebonite, etc., their resistivity steadily increases. The enormous increase in resistance of bismuth, when transversely magnetized and cooled, was also discovered in the course of these experiments. The study of dielectric constants at low temperatures has resulted in the discovery of some interesting facts. A fundamental deduction from Maxwell's theory is that the square of the refractive index of a body should be the same number as its dielectric constant. So far, however, from this being the case generally, the exceptions are far more numerous than the coincidences. It has been shown in the case of many substances, such as ice and glass, that an increase in the frequency of the alternating electromotive force results in a reduction of the dielectric constant to a value more consistent with Maxwell's law. By experiments upon many substances, it is shown that even a moderate increase of frequency brings the large dielec-

tric constant to values quite near to that required by Maxwell's law. It was thus shown that low temperature has the same effect as high frequency in annulling the abnormal dielectric values. The exact measurement of the dielectric constant of liquid oxygen, as well as its magnetic permeability, combined with the optical determination of the refractive index, showed that liquid oxygen strictly obeys Maxwell's electro-optic law even at very low electric frequencies. In magnetic work the result of greatest value is the proof that magnetic suceptibility varies inversely as the absolute temperature. This shows that the magnetization of paramagnetic bodies is an affair of orientation of molecules, and it suggests that at the absolute zero all the feebly paramagnetic bodies will be strongly magnetic. The diamagnetism of bismuth was found to be increased at low temperatures. The magnetic moment of a steel magnet is temporarily increased by cooling in liquid air, but the increase seems to have reached a limit, because on further cooling to the temperature of liquid hydrogen hardly any further change was observed. The study of the thermo-electric relations of the metals at low temperatures resulted in a great extension of the well known Tait thermo-electric diagram. Tait found that the thermo-electric power of the metals could be expressed by linear function of the absolute temperature, but at the extreme range of temperature now under consideration this law was found not to hold generally; and, further, it appeared that many abrupt changes take place, which originate probably from specific molecular changes occurring in the metal. The thermo-electric neutral points of certain metals, such as lead and gold, which are located about or below the boiling point of hydrogen, have been found to be a convenient means of defining specific temperatures in this exceptional part of the scale.

The effect of cold upon the life of living organisms is a matter of great intrinsic interest, as well as of wide theoretical importance. Experiment indicates that moderately high temperatures are much more fatal, at least to the lower forms of life, than are exceedingly low ones. Professor McKendrick froze for an hour at a temperature of—182° C. samples of meat, milk, etc., in sealed tubes; when these were opened, after being kept at blood heat for a few days, their contents were found to be quite

putrid. More recently some more elaborate tests were carried out at the Jenner Institute of Preventive Medicine on a series of typical bacteria. These were exposed to the temperature of liquid air for twenty-four hours, but their vitality was not affected, their functional activities remained unimpaired, and the cultures which they yielded were normal in every respect. The same result was obtained when liquid hydrogen was substituted for air. A similar persistence of life in seeds has been demonstrated even at the lowest temperatures; they were frozen for over a hundred hours in liquid air, at the instance of Messrs. Brown and Escombe, with no other result than to affect their protoplasm with a certain inertness, from which it recovered with warmth. Subsequently, commercial samples of barley, pea, vegetable marrow, and mustard seeds were literally steeped six hours in liquid hydrogen at the Royal Institution, yet when they were sown by Sir W. T. Thiselton Dyer at Kew in the ordinary way, the proportion in which germination occurred was no less than in the other batches of the same seeds which had suffered no abnormal treatment. Bacteria are minute vegetable cells, the standard of measurement for which is the "mikron." Yet it has been found possible to completely triturate these microscopic cells, when the operation is carried out at the temperature of liquid air, the cells then being frozen into hard breakable masses. The typhoid organism has been treated in this way, and the cell plasma obtained for the purpose of studying its toxic and immunizing properties. It would hardly have been anticipated that liquid air should find such immediate application in biological research. A research by Professor Macfadyen, just concluded, has shown that many varieties of microorganisms can be exposed to the temperature of liquid air for a period of six months without any appreciable loss of vitality, although at such a temperature the ordinary chemical processes of the cell must cease. At such a temperature the cells cannot be said to be either alive or dead, in the ordinary acceptation of these words. It is a new and hitherto unobtained condition of living matter—a third state. A final instance of the application of the above methods may be given. Certain species of bacteria, during the course of their vital processes, are capable of emitting light. If, however, the cells be broken up at the tem-

perature of liquid air, and the crushed contents brought to the ordinary temperature, the luminosity function is found to have disappeared. This points to the luminosity not being due to the action of a ferment—a "Luciferase"—but as being essentially bound up with the vital processes of the cells, and dependent for its production on the intact organization of the cell. These attempts to study by frigorific methods the physiology of the cell have already yielded valuable and encouraging results, and it is to be hoped that this line of investigation will continue to be vigorously prosecuted at the Jenner Institute.

THE RELATION OF PHYSICS TO MEDICINE.*

BY WINFIELD S. HALL.

Professor of Physiology, Northwestern University Medical School, Chicago.

It may come as a surprise to some of us that there can be anything more than a remote relation between the science of physics and the practice of medicine. But we must not forget that the legitimate practice of medicine today deals with the physical body governed by physical laws, and it may be said in brief that the problems of scientific medicine are either problems of physics or of chemistry. It may be of interest here for us to recall for a moment some points in the life of one of the great physicists. Helmholtz, that world renowned expounder of your science, was a great physicist and he was also a great physiologist. Some of you may not know that Helmholtz received the degree of Doctor of Medicine from the University of Berlin about the year 1847 on a thesis entitled "The Nervous System of the In-

* In response to a toast at the banquet of the Central Association of Physics Teachers, November 28, 1902.

vertebrates." The two professors who influenced him most were Johannes Müller, the great pioneer in experimental physiology, and Magnus, the inspired teacher of experimental physics. Associated with Helmholtz as students were Du Bois Reymond, Virchow, Brücke, Claussius, Kirchhoff, Quincke, Seimens, Tyndall, and Wiedemann, who were masters in their several fields of experimental science. You remember that Helmholtz published a brief classic on the "Conservation of Energy," in 1847, and though he was not the first to formulate this theory, it was he who presented it in such a form as to bring it forcibly to the attention of the scientific world. Helmholtz's first professorship was at Königsberg where he was head of the department of anatomy, physiology and pathology. In this position his earliest work was in anatomy, on the mechanics of respiration. His attention soon, however, was turned to the physical problems of physiology, for which work he was especially well adapted by training as well as by his natural inclination. His first work was to determine *the velocity of nerve impulses.* Then followed his exhaustive work in optics. The earliest achievements being the invention of the *ophthalmoscope,* followed soon by the *ophthalmometer.* These instruments have been of inestimable value to the medical profession. He continued his activities in the field of physiologic optics until it bore fruit in that classic work: *"Physiological Optics"* ("Physiologische Optik."). He turned his attention then to the problems of physiological acoustics, resulting in his classic work on science of sound ("Tonempfindung"). This work is of inestimable importance to physiologists, psychologists, physicists, and to musicians. After twenty-two years spent as teacher of the physical problems of physiology, Helmholtz was called to the University of Berlin as Professor of Physics, which position he held until his death.

I have spoken thus extensively of the work of Helmholtz in order to show once for all the intimate relation between physics and medicine. I have said that the problems of physiology are problems of physics or of chemistry and the better preparation the student has in these two sciences before he enters upon the

study of medicine the more secure will his foundation be and the more sure his success in the practice of scientific medicine. It will be of interest to you to hear the enumeration of the chapters of physics in which the student of medicine must possess a good working knowledge.

In order to be enabled to solve problems of locomotion it is necessary that the student be thoroughly acquainted with *mechanics.* He should be able to compute the number of work units performed by a muscle in transporting the body through space under various conditions. He should be able to translate this work unit into heat units and this in turn into food units. He must be acquainted with the principles involved in the transformation of energy.

If he is to be able to solve the problems involved in circulation and respiration he must be acquainted with the principles of *hydraulics,* the laws which govern the absorption of gases by liquids and the laws which govern the diffusion of gases.

A knowledge of heat formation, condensation, diffusion, of thermometry, of vaporization, of radiation, and of calorimetry, will be requisite.

A working knowledge of *acoustics* will be necessary if he is to understand the functions of the vocal organs and the organs of hearing, and if he is to be able to treat these organs successfully in his capacity as a practitioner of medicine. No less thorough knowledge will be necessary in *optics*—a knowledge of reflection and refraction of refractive media, prisms, lenses and of optical instruments.

Electricity is used as a stimulus in the physiological laboratory. It is used for the diagnosis of various diseases of the neuromuscular apparatus and it is used in the treatment of various diseases. In order to use this most valuable agent in physiology and practical medicine intelligently, the student must be acquainted with the principles of various cells and batteries. He must have a thorough knowledge of the application of Ohm's law, and be able to compute accurately the amperage of his current, given the voltage of his cell and the resistance of the circuit and the method in which the circuit is joined up. He must be acquainted with

various electrical appliances such as the inductorium, rheostat, and galvanometer.

From this brief outline of the course in physics which every student of medicine should master before he enters upon the study of medicine there can be no doubt as to the relation between physics and medicine. It is the same relation that the foundation bears to the superstructure. The stability of the latter depends upon the stability of the former. Medical practice in the times of our grandfathers was securely ensconced behind the vail of mysticism. Modern science and research have rent this vail asunder and we approach the problems of medicine today with the same spirit and same methods that the physicists and chemists use to solve the problems of their sciences. As your science of physics grows, so will our science of medicine grow. The future has many triumphs in store. You will lead the way and we of the medical profession will follow.

WHAT OF CHEMISTRY SHALL BE TAUGHT IN THE HIGH SCHOOL AND HOW SHALL IT BE MOST EFFECTIVELY TAUGHT?

BY L. M. DENNIS,

Professor of Inorganic and Analytical Chemistry, Cornell University.

Most educators are agreed that instruction in at least one of the natural sciences should be included in the curriculum of high schools and preparatory academies. Among these sciences, physics and chemistry occupy positions of prominence, and instruction in one or both of these subjects is usually offered. Before speaking to the question, "What of chemistry shall be taught in the high school and how shall it be most effectively taught?" let us consider for a moment the conditions under which it is desirable to teach both physics and chemistry in the high school and which of the two sciences should be selected if only one is to be offered.

There are two distinct aims in the teaching of science in the high school. The first of these is the cultivation of the habit

of close observation and of accurate deduction from observed phenomena; the second is the imparting to the student of information intended either merely as an addition to his fund of general knowledge or as preparation for advanced work in this line in some higher institution of learning. Regarding the first point, it is, I believe, true that a scientific habit of thought may be equally well developed by properly conducted courses in either physics or chemistry, yet instruction in physics should precede that in chemistry, because an understanding of the phenomena of heat and electricity and of the laws of mechanics will be of great aid to the student of chemistry and is indeed an almost indispensable preliminary to the profitable performance of his work. If then, in arranging the course of study for the high school, it is felt that time can be found for only one of these sciences, physics should undoubtedly be given the preference.

Touching the second point, the imparting of information to the student, it will generally be conceded that if the education of the student is to terminate with the high school course, the knowledge that he will acquire in the study of physics will be of fully as great utility to him in after life as that derived from a course in chemistry. The instruction which can be given in a high school in either of these branches can not make of a student either a physicist or a chemist. Consequently it is futile to argue that a high school preparation in one or the other of these sciences will be sufficient to enable the pupil to use the knowledge thus acquired as a means of gaining a livelihood, and that consequently one who is intending to fit himself as a chemist should receive in the high school instruction in chemistry even to the exclusion of physics. No one can hope to become a properly trained chemist unless he is thoroughly grounded in the other science. As has been said by one of the greatest teachers of science of the preceding century, "a chemist who is not a physicist is nothing at all." Hence there will be no gain in time for the student of chemistry, if he be given chemistry instead of physics in the high school, for instruction in the latter subject must be received either then or at some later time in his training. It would seem, therefore, whatever the aim in view, that the curriculum of a high school should first of all provide a thorough course in physics, ac-

companied by laboratory instruction, and that chemistry should be taught only when time will permit of its following a year of training in the other science.

This brings us to the question of the "What" and "How" of the chemistry to be offered to the high school pupil. If the teacher is well fitted for the work and the facilities for class room and laboratory instruction are adequate, no branch of science will prove of greater profit and interest than chemistry, to the student properly prepared to undertake it. The preparation of the teacher should include *at the least* a year of lecture, recitation and laboratory instruction in general inorganic chemistry amounting to about six actual hours a week (or the equivalent of such a course), together with a full year devoted to qualitative and quantitative analysis. If this can be supplemented by training in elementary organic chemistry, and a brief course in physical chemistry, the effect will soon be manifest in the greater success of the teacher, a greater power to make the subject a "live" one to the pupil, and in the greater enthusiasm and clearer understanding on the part of the student.

Yet no matter how complete may have been the training of the teacher, it is hopeless to expect to obtain satisfactory results if suitable laboratory facilities are not at hand. And it is exactly in this respect that many of the high schools in our smaller cities and towns labor under serious disadvantages. A laboratory for instruction in physics can be installed in a room of usual construction and can be equipped once and for all by the purchase of a suitable stock of apparatus. A chemical laboratory, on the other hand, should be especially planned for the purpose for which it is to be used. It must have large table space, a more or less elaborate system of plumbing, adequate ventilation not merely of the "hoods" for carrying off noxious gases, but also of the entire room, and it must be equipped with a large stock of chemicals and fragile glass apparatus, which must be constantly renewed. If the money available for the teaching of science in the high school is not adequate to properly construct, equip and maintain such a laboratory, then again it will be wiser to concentrate upon physics rather than to attempt to offer chemistry under unfavorable conditions.

The course in chemistry should first of all comprise a full year of work in general inorganic chemistry, with experimental lectures, laboratory practice, and recitations. It is unfortunate that in certain schools some qualitative analysis is included in this first year of chemistry; the time is none too great for inorganic chemistry alone, and the small amount of qualitative analysis that can be given in connection with the inorganic chemistry will prove of but little benefit to the student. If anything is to be added to the inorganic chemistry in the first year, let it rather be a brief study of the commoner compounds and processes of organic chemistry.

Both in the lectures and the recitations, it is inadvisable to make early use of the symbols or formulæ or of equations to express chemical reactions. If the student begins with the study of hydrogen and prepares that gas himself in the laboratory, we should not insist that he learn at that time either the formulæ of the substances which he uses or of the products which are formed. At this early stage it is quite sufficient that he know that zinc and sulphuric acid, when brought together, will set free a gas that is termed hydrogen, and that he then ascertain the properties of this gas by actual experiment.

As preliminary to the work of the laboratory, brief instruction in the setting up of apparatus should always be given by the teacher. Students should be shown how to draw out, bend and join glass tubing, how to clean chemical glassware, and how to properly support the different pieces in position. Skill in the handling of apparatus is a most essential acquisition for a chemist, and proper training in this matter thus early in his career will save him from many vexatious delays and even failures in his later work. At the beginning of each period of laboratory practice, the teacher should explain to the class what is to be done and should set up the apparatus that is to be used. Each student should then be required to neatly and properly put together the apparatus for each experiment, following the model which has been shown to him. Careful observation and accurate statement of experimental results by the student should be culti-

vated, and he should be impressed with the importance of "experimental honesty." By that I mean that he should be encouraged in stating exactly what he has seen in the experiment and should not be given the idea that if his results do not agree with the statements in the textbook, his work will be regarded as a total failure. The experiment should, of course, be repeated until proper results are obtained, and the understanding of the reasons for the failure and for the subsequent success will then double the value of the work to the pupil. Indeed, many chemists are wont to say that more can be learned from an experiment that has "failed" than from one that has succeeded, and it is a fact that some of our most important discoveries have thus been made. Training in accuracy of manipulation, observation and statement should, therefore, be the first object of the teacher, and a carelessly performed experiment, which happens to agree in its results with the statements in the textbook, should be regarded as half a failure.

I trust that what has been said will not be regarded as in any way intended to discourage the teaching of chemistry in the high school, when the conditions are favorable. On the contrary, it is earnestly to be hoped that the instruction in this subject will be constantly extended, provided always that it is of a high standard of excellence and is offered to students properly fitted to reap its benefits.—*American Education.*

WEATHER WORK IN THE SCHOOLS.

BY H. W. HARMON.

Department of Science, Southwestern State Normal School, California, Pa.

The U. S. Weather Bureau is attempting to extend its usefulness in all practical directions. One sees in the various weather bureau reports and bulletins statements to the effect that the more completely the people at large understand the weather maps, forecasts and elements of weather, the more effective the work of the bureau will be. And if the growing generation in the schools be instructed along these lines the utility of this already very useful branch of our government will be increased many fold.

With this in mind, as well as the fact that the study of the weather is a useful, interesting and practical division of the subject of physics, there was planned for the four divisions of our class in physics (numbering about 110) a scheme of weather observing. This was regarded as a part of the laboratory work and was so arranged that each of the members of the class should have one week at least of observing sometime during the school year.

Our normal students, under training soon to become teachers in grade schools and high schools, would expect work of whatever nature to stand the test of practical use in their own schools. This was deemed possible by simplifying and reducing somewhat the extent of the observations to meet the conditions of their schools.

If this be so for the grade schools and to a much fuller extent for high school students studying physics, large numbers of these young people, soon to be a part of the world's active life, would be somewhat grounded in the principles governing weather, and able to make good use of the weather bureau forecasts, maps, bulletins, etc.

The plan of student observation was this:

Each of the four divisions of the class was represented by one of its number, thus making a group of four observers. These four students took observations from the various instruments for

one week. The following week a new group of four replaced them, and so on throughout the year.

The report on these observations was in the form of what we call the physics thesis, the general thesis subject being "Weather." In this thesis would be found the report of the weather of the whole month in which the observer's week came, also in more minute detail the weather of the observer's own week and the weather conditions carefully analyzed and related. The curves of barometer, mean temperature, dew point and wind direction changes for the month, would be drawn and by these and from the record data the rules given for forecasting weather changes were to be verified or disproved (these rules to be enclosed in the report). Other rules their observations might suggest were to be given. The instruments used were to be briefly described and method of use and principle explained. Drawings of instruments, flag signals, storm centers, weather maps, etc., were often inserted to illustrate or aid in explaining the various topics.

Especial emphasis was laid on originality and careful thought in the relating of the various weather factors; thus it could be regarded as evidence of the student's ability to handle thoroughly and well such a subject. The thesis reports were due by the 30th of the following month. The weather work was made a part of the daily recitation work. Early in the year before starting the student observations, lantern slides of the various instruments and typical weather-map storms were thrown on the screen and explained. The principles involved in the barometer, thermometer and hygrometer were assigned as lesson topics. This being finished, observation groups were started. Partial records of the weather factors were placed on the black board each day(barometer, wind direction, dew point, per cent of moisture, locality of the storm center, amount of rain, temperature and sky), and the first two or three minutes of each recitation period were spent in the discussion of weather conditions, the group members being leaders. Much interest has been taken in these brief discussions.

The instruments used are the rain gauge, maximum and minimum thermometer (these together with the instrument shelter being supplied by the Weather Bureau, this being a volunteer station), wet and dry bulb and hair hygrometer, barometer (we

use both mercury and aneroid to check each other) and wind vane. The motion of smoke gives a chance to estimate wind velocity and clouds are named by comparing with those of the U. S. Hydrographic Office Cloud Chart.

The observations are recorded in the laboratory record book and also each observer keeps his own record for his week.

The observations of instruments were made at 8:00 a. m. and 4:00 p. m. each day. The group observers, after completing the observations, compare them with those of the previous time and from the rules for forecasting and the position of the storm center shown on the latest weather map, make their predictions for the next 12 or 24 hours. They then display the proper weather signal flags from a small flag staff fastened to the instrument shelter. Keen interest is taken in the outcome of their prediction. The whole school understands their meaning and the group wish success to avoid the fun poked at the "weather man" by their classmates. However, a large part of the observers have been quite successful in their forecasts.

The following are the summarized rules used in forecasting:

WEATHER INDICATIONS.

Barometer Changes.

Rise = Fair weather or a clearing up of a storm.
Fall = Approach or increase of storm.

Humidity.

1. Slight changes of dew points—Fair weather.
2. Wide changes of D. P.—Foul weather.
3. Rising dew point—Warmer.
4. Falling dew point—Cooler.
5. Rapidly fluctuating D. P.—Windy.
6. Rapid rise of dew point to 70° F. with muggy air—Thunder storm.
7. Falling dew point to 32° with clear sky and no wind—Frost.

Winds.

1. North. Slight rain or snow (with falling barometer).
2. North-east, east or south-east. Heavy rain or snow.
3. South. Slight rain or snow.

4. South-west, west or north-west. Fair and cooler (with rising barometer).

5. Winds shifting from north-west to south-west and to south. Approach of another storm. ("When wind veers against the sun, trust it not for back it will run.")

NOTE I.—Storm center is to the left of the wind direction. Point the fingers of the right hand in the direction the wind is going and the thumb will be pointing toward the storm center. Fair weather is to the right of the wind direction.

NOTE. II.—The wind velocity is higher as the amount of barometer difference between the "Low" and "High" is greater.

Clouds.

1. Cirrus or cirro-stratus with falling barometer. Approach of bad weather or distant storm. "Mares tails and mackerel scales make lofty ships carry low sails."
2. Alto-stratus, cirro-cumulus, strato-cumulus, fracto-cumulus and nimbus with falling barometer. Rain or snow.
3. Same in reverse order with rising barometer. Fair weather.
4. Cumulus, rapidly forming with high humidity. Thunder storm.
5. Alto-cumulus at Sunset. Fair.

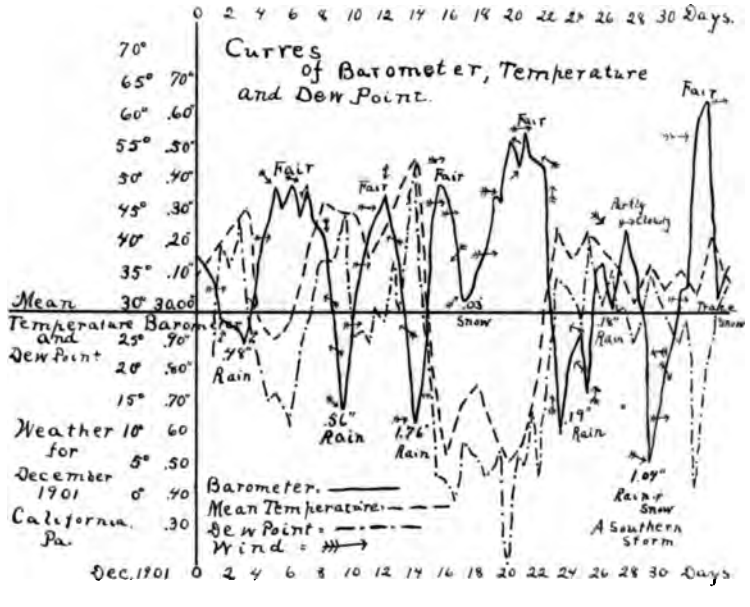
Sky.

1. Fresh blue. Fair weather.
2. Pale blue. An approaching storm.
3. A clear stretch of sunset, red close along the horizon, this surmounted by yellow, indicates fair weather for following day.
4. A LURID western sky, a sunset with colors spread above the horizon on thin cirrus clouds. Storm coming.
5. Dirty and dull with sky in east clearer. Storm nearer.
6. Rainbow, in east, "at night sailor's delight; rainbow in morning sailors take warning."
7. Halo around sun or moon. Approach of storm.

To save the students time, a printed weather record blank has been in use. The various weather factors are recorded on it and on its back is the monthly summary. The size of the blank 15″x15″, to be folded in the middle and from the bottom to fit the covers of the Science Tablet Physics Record (Central School

Supply House, Chicago). The thesis is written up on the writing sheets, illustrated on drawing sheets, and curves drawn on co-ordinate paper prepared for these covers, and thus, it is, when completed, for the student teacher, a well-bound, condensed, elementary treatise on weather for their future use. The students seem to have found the weather an especially interesting subject, and the reading through of their theses has time and again given me the above impression.

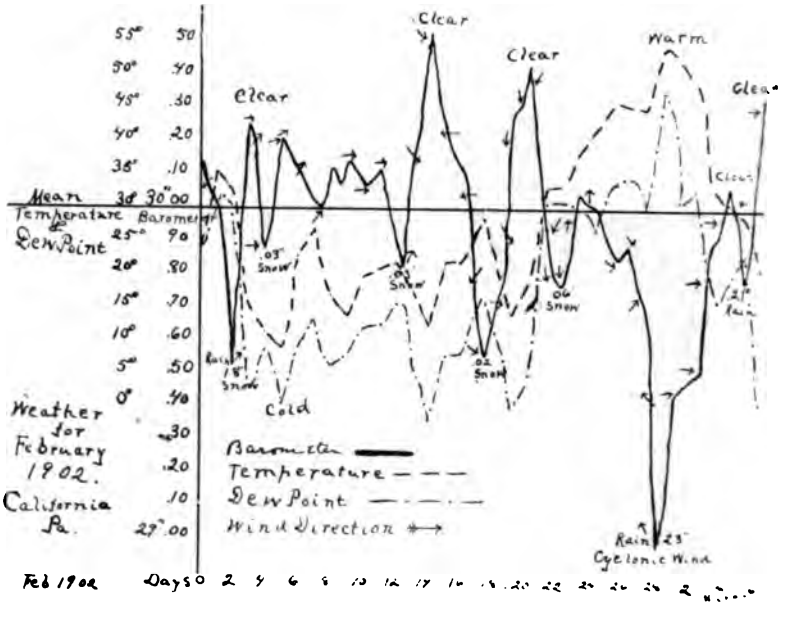
The curves showing the changes in the barometer, mean tem-



perature, dew point and wind direction, drawn on the same sheet of cross-section paper, the origin being the same for each, days of month for abcissa, and pressure and mean temperature for ordinates, show very graphically the very close relations between these four most important weather factors. The accompanying curves for the month of December and February being typical diagrams of a month's weather changes. The number of lowest barometer points with the accompanying cloudiness, rain or snow, indicates

the number of storms passing during the month, and the number of high points with the accompanying "Fair" weather, the number of "Highs" or anticyclones. A glance shows the dew point and temperature curves rising together as the barometer falls, and falling when it rises. Also the wind directions which bring the rain and the fair weather.

Being on the Monongahela river, and as it frequently varies in level from low water to flood levels, the students have been



studying the relation between rainfall and river rises. They determine the ratio between the amount of rainfall in inches to the rise of the river in feet, the soil conditions being taken into consideration, and are thus able to forecast river stages.

This, and more or less all of this work, has not a little of the element of original investigation in it, and all have become more close observers of the varying phenomena of nature around them.

The children of even the lower grades can and do take interest in the simpler weather elements, such as the wind direction, the clouds, the rain or snow, and with but a little instruction can learn to record the changes in the barometer. A teacher can, with little difficulty and but trifling expense, construct or supply, a more or less accurate wind vane, rain gauge, cheap thermometers, a hygrometer; also with glass tubing and a little mercury could make a fairly accurate siphon barometer and thus have instruments for taking all of the most important weather factors.

Weather work, therefore, seems to have in it elements of interest, educational value and practical utility for children in the lower grades and in grades up to that of the most advanced students.

THE DETERMINATION OF THE WEIGHT OF A LITER OF AIR.

BY C. E. LINEBARGER.

In Volume I, page 28, of this journal, is given a method of determining the weight of a given volume of air.* While the method is excellent for demonstration purposes it is hardly simple enough to put in the hands of pupils. The following simplifications, however, make it well adapted to student's use. The apparatus is such as can be obtained in abundance at almost no outlay of money.

The top of a "tomato can" is melted off and the melted off bottom of another can soldered on in its place. A hole about 3 mm. in diameter is pierced in the can thus prepared and a bicycle valve soldered over the hole. It is very necessary that the valve be air-tight even when its cap is not screwed on.

The valve is connected with a bicycle pump and air pumped into it. The sides of the can will bulge out somewhat, but if

* A Convenient Method of Determining the Density of Air, by A. W. Augur.

the soldering has been done with care, the pressure may be brought up to about three atmospheres without any danger of the can springing a leak. It is perfectly safe to pump in as much air as possible as the can will always spring a leak at its weakest point and will not explode as a glass vessel would.

The can thus filled with compressed air is weighed to centigrams. It is then connected by a piece of ordinary rubber tubing with a large aspirating bottle, a match with its head broken off being placed beforehand in the tubing just over the valve. Precautions having been taken to have the pressure of the air in the aspirator equal to that of the atmosphere, the rubber tubing is pinched just over the valve and the match stick thus grasped, is pushed down so as to open the valve a little. This is repeated until no more air escapes from the can.

As the air in escaping from the can is cooled by the expansion it is necessary to wait several minutes before disconnecting so that the air may be warmed to the temperature of the room again. The valve should be kept open for a minute or so when the overflow vessel is so arranged that the level of the water in it is the same as that of the water left in the aspirator.

The can is now disconnected and weighed. The volume of the water which has been driven out of the aspirating bottle is measured and reduced to standard conditions.

The method recommends itself not only for its simplicity and excellence of results but also for the cheapness of the materials. A teacher has only to ask his pupils to bring in cans and bicycle valves to obtain for nothing a plentiful supply, and the labor of preparing the cans is but slight. When once a stock is on hand it is ready for use at a moment's notice.

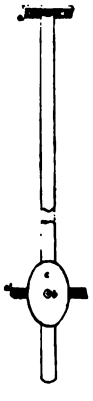
A METHOD OF DETERMINING THE VALUE OF GRAVITY.

BY F. H. FOSTER,

Instructor in Physics and Chemistry, Princeton (Ill.) High School.

A problem, which I have almost invariably found to be of interest to my pupils, is that of finding the local value of the earth's gravity. Unfortunately, the method of determining this constant by means of the ordinary pendulum gives such poor results that it is usually valueless. Several years ago I devised a simplified form of Kater's pendulum, which has proved so satisfactory that I offer it with the hope that others may find it useful.

The apparatus consists of a brass rod, about 150 cm. long, with a diameter of one centimeter. The rod may be suspended from one end by a steel knife-edge, *a*. Another knife-edge, *a'*, facing the former, is attached to a brass ellipsoid, sliding on the rod, and provided with a setscrew, *b*. At each end of the pendulum is soldered a platinum wire, making contact with a drop of mercury in electrical connection with a telegraph sounder. The apparatus may be suspended from steel bearings, adjusted on either side of a slot cut in a wooden shell. It is convenient to have two sets of bearings and two slots of varying width.



The rod is first suspended from *a* and an approximate value of this vibration-period obtained. It is then suspended from *a'*, and the slide adusted until the time is about the same as from *a*. In practice it is well at this point to have the student determine clearly the effect on the time of both sets of vibrations of successive small movements of the slide. Finally, by carefully adjusting the movable knife-edge, the time of one or two thousand vibrations will be the same, taken from either point of suspension. An accurate measurement of the distance between the two knife-edges will now

give the length of the simple pendulum having the obtained vibration rate. A good stop-watch is needed; or, by lightly touching and releasing the balance wheel, estimating to fifths of a second, an ordinary watch may be successfully used. My students have obtained results differing from the computed value by about .03 of one per cent.

THE VOLUMETRIC SYNTHESIS OF WATER AS A PRACTICAL QUANTITATIVE LECTURE EXPERIMENT.

BY ERNEST F. BURCHARD,

Instructor of Chemistry, Sioux City (Ia.) High School.

In order to illustrate this phase of the Law of Gas-volumetric proportions to a nicety, and that the experiment may at the same time become a working exercise for the class in the application of the Law of Charles, the essential piece of apparatus is a special eudiometer, *E*, (Fig. 1) at least 50 cm. in length, with a stopcock at the top, and is graduated to 1/10 cc. from the stopcock downwards. Its total capacity should be about 60 cc., and the lower end should be ungraduated and tapered slightly with a swell or ring at the terminus for secure fastening of a rubber tube. The platinum wires pass in at the shoulder, just below the stopcock.

This eudiometer is enclosed by a steam jacket, *J*, a tube of good, clear glass, 45 cm. long, 5 cm. inside diameter, and 3mm. wall. A stout triple-bored rubber stopper fits the bottom, and through it pass the eudiometer and two small tubes, one for the admission of steam, the other to drain off water. To the lower end of *E* is securely fitted at least 75 cm. of fresh, clean (preferably antimony) rubber tubing of 6 mm. inside diameter and 3 mm. wall, to the other end of which is cemented a 6 cm. glass funnel. The whole is supported in an upright position, and

a convenient rest for the funnel is made by sawing a small section out of a small iron ring, in order to slip the funnel easily in and out.

When the apparatus is ready it must be thoroughly dried by a continued blast of hot, dry air, after which the stopcock is closed, the funnel corked, and the whole allowed to cool, after which the eudiometer may be completely filled with mercury that is known to be clean and dry. (It is best to subject the mercury

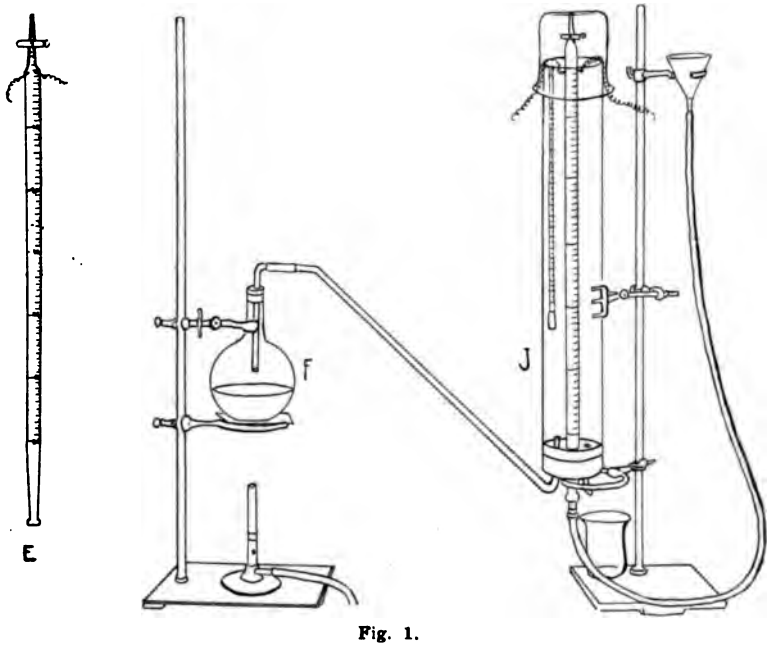


Fig. 1.

to a thorough cleaning, warming and drying in a dessiccator before using it.) The mercury should about half fill the funnel. The electrolytic gas is generated in the usual way, by electrolysis of pure water acidulated with H_2SO_4, and dried by passing through calcium chloride and concentrated sulphuric acid, from which wash bottle it is passed into the eudiometer after having continued in action for a safe interval. It is essential that the electrolysis apparatus and wash bottles be stoppered absolutely

tight. It may be most convenient to place the gas delivering apparatus on a box in order to bring it near the level of the top of *E*. The gas is admitted to the top of the eudiometer, the tube above the stopcock having been filled to the brim with mercury. While the gas is passing in, the funnel is slowly lowered, until about 10 cc. of the gas is in the eudiometer at atmospheric pressure.

The levels of the mercury in the funnel and within the tube may be most accurately adjusted by a student, who receives his directions from the instructor observing the apparatus through a reading telescope from the rear of the lecture room. A thermometer hangs within the steam jacket, and the original volume, temperature, and barometric pressure, with temperature correction, are recorded. It is best now to cover the top of the jacket with a long, inverted beaker, which fits the outer tube closely, as the heat is thus much more satisfactorily retained. Steam is now passed into the jacket from flask, *F*, and allowed to continue until the interior has become almost clear of condensed drops of water, the hot water running down cleanly, and the temperature maintaining a constant degree for at least seven minutes. This entire heating need not occupy more than twenty minutes. Of course, the water flask should be at boiling point and in readiness before being connected. The levels are once more equalized as before, and the records of volume, pressure and temperature again made, the steam continuing to pass into *J*. At this point, the pressure may be reduced one-half (and it may be necessary to pour out some of the mercury from the funnel when it is so lowered). A spark is passed through the eudiometer from a Ruhmkorff coil or from a Wimshurst machine, and the gases exploded. The levels are now readjusted, and the volume, temperature and pressure recorded. The steam may then be discontinued, and the apparatus allowed to cool until the steam within the eudiometer has condensed, and the effect on its volume observed and noted.

If the electrolytic mixture of hydrogen and oxygen has been pure and dry, and the mercury and interior of the eudiometer have been clean, dry, and all air has been excluded, very accurate results may be expected from the experiment, and the residual

gas, after exploding and cooling, will be inappreciable. Considerable time is, of course, necessary in preparation for this work, and a preliminary trial is advisable, but the actual operation may be successfully carried out in one recitation period, with the exception of allowing the apparatus to cool fully to the temperature of the room, provided everything is in readiness.

The special eudiometer may also be used to demonstrate the Laws of Boyle and Charles, separately or combined.

The following data were obtained in a class-room experiment as outlined above:

I	II	III	IV
Original Hydrogen + Oxygen	Same after heating	After exploding	After cooling
V = 9.88 cc.	V = 12.5 cc.	V = 8.3 cc.	V = 0.15 cc.
T = 21°.5	T = 98°.7	T = 98°.7	T = 25°.0
P = 727 mm.	P = 727 mm.	P = 727 mm.	P = 727 mm.

In the pupil's report, besides the description of the usual details, drawings, and records, answers may be expected to some such leading questions as these: What volume would 9.88 cc. of a mixture of hydrogen and oxygen at 21.°5, and 727 mm. pressure occupy when heated to 98.°7, the pressure remaining the same? How does this correspond with the observed volume? What percentage of the original volume of gas at 98.°7 remains after the explosion, the temperature and pressure both remaining constant? What is the resulting gas? What becomes of it when cooled? Has any matter been lost or destroyed during the experiment? How do you account for the change? Has the proposition (what was it?) been proved?

Metrology.*

SYSTEM IN METRIC WEIGHTS AND MEASURES.

(*Concluded from page 413.*)

A practical illustration of the importance attached to correspondence between different kinds of measures is found in the measure used by mariners of one second of arc on the earth's surface. Why should this be called a (nautical) *mile?* Simply because the real mile used for measurement on land is but a little shorter. It really causes confusion between the measurement established on land and at sea, and sometimes serious mistakes.

But the people of the United States have thought that it was convenient to have the minutes of an arc called a mile, even in spite of its lack of exactness. Their Public Land System, by the way, lays out townships by meridians and parallels run astronomically.

Even if the different systems above outlined had been more complete, their use in combination with one another would have been inconvenient from their conflicting. What is wanted is to have the same arithmetical progression in large as well as small denominations of any one kind of measure, in multiples as well as in subdivision; also to have the same arithmetical system in all kinds of measure; also to have the units of measure of different kinds related to one another. It is this completeness of system which makes the metric weights and measures so very much more convenient than the grotesque confusion of fragments of various systems long customary in the United States. The metric system affords a much better mental grasp of magnitudes and their relations to one another, and is much easier to learn and remember. This has been tersely stated in some leading articles of *Engineering* (London) from which the following sentences are quoted:

"No one can be so dense as not to be able to understand its main features in two minutes. In the decimetre—any other name would do as well or better—we have a convenient standard of

* Communications for the Department of Metrology should be sent to Rufus P Williams, North Cambridge, Mass.

length. A cube of this dimension furnishes the unit of capacity, the litre, while the weight of a litre of water is the unit of weight, the kilogramme. That is the whole of the metric system, and it passes the wit of man to devise one simpler or more convenient." (Vol. 67, p. 519, April 21, 1899).

"Its grand features are that it is based on a single unit both for measures of length, measures of weight, and measures of quantity, and that it admits only one divisor. The gain implied in these two propositions is so immense as to completely overshadow all the criticism that can be brought to bear on its less satisfactory features." (Vol. 61, pp. 509-10, April 17, 1896.)

The convenience resulting from this systematic quality in the practical application of the metric units to various kinds of work was pointed out in an excellent paper on the Metric System of Weights and Measures, read by A. Hanssen before the Civil and Mechanical Engineers' Society and printed in *Engineering* (London), v. 67, pp. 295-6 (March 3, 1899); from it a few quotations may be made:

"Take, for instance, a substance like cast iron, the weight of which we constantly have to calculate from the volumes shown on drawings or described in specifications. Its average specific gravity is 7.23, that is to say, it weighs 7.23 times more than an equal volume of distilled water. This single figure tells us at once that a cubic centimetre weighs 7.23 grammes, a cubic decimetre weighs 7.23 kilogrammes, and a cubic metre weighs 7.23 tonnes. A plate 1 square metre in area and 1 millimetre thick has a volume of 1 cubic decimetre, and it is therefore easily remembered that sheets of cast iron weigh 7.23 kilogrammes per square metre for each millimetre in thickness. If we have a given weight of cast iron, and want to know what volume it occupies, we only have to divide the weight by this one magic factor of 7.23. To convert the grammes and kilogrammes into tonnes it is necessary to insert the usual comma for every three figures of the result."

"With the metric system the quantity of water to be lifted is given in litres or cubic decimetres per second, the speed of the piston is given in decimetres per second, and a division of the first figure by the second gives the area of the pump in square decimetres. The diameter is found from this in decimetres, and we have only to move the decimal point to make them into millimetres."

"This reduction of work by using the metric system, holds good for most calculations made by engineers and architects. The

amount of unnecessary work done by quantity surveyors for the building trades, when taking out quantities, is immense. On the Continent all dimensions are in metres, and one or two multiplications give at once all quantities in squares or cubic metres."

"In the metric system the mean pressure of the atmosphere at sea-level is almost exactly equal to 760 millimetres of mercury, which is equal to a column of water 10.333 metres high or to 1.0333 kilogrammes per square centimetre. Slight pressures, such as the pressure of coal gas, or the vacuum in a chimney stack, are expressed in millimetres of water, of which 10,333 are equal to an atmosphere, or by kilogrammes per square metre, of which, again, there are 10,333 to an atmosphere. These measures are readily interchangeable without any calculation, and depend upon the fact that a tube 10 metres high, with a sectional area of 1 centimetre, will contain exactly 1 litre of water, which will weigh 1 kilogramme, and the pressure exerted by the water in the tube against its base is, therefore, equal to 1 kilogramme per square centimetre for each 10 metres iiin height."

One way in which the superior simplicity of relations among metric units is manifested is in the assertions put forward by opponents who argue that old weights and measures are used conveniently by the application of ingenious approximations toward relationship which for various classes of calculation have been devised and are remembered by the special workers in those classes of work. One very eminent man who has emphasized this would-be adverse argument was Sir Frederick J. Bramwell, formerly president of the Institution of Civil Engineers of Great Britain. He presented his idea embodied in which he called "Short Cuts," before the special committee of the House of Commons which heard a great deal of evidence in 1895.

Sir Benjamin Baker, who has also been president of the Institution of Civil Engineers, was examined immediately afterwards, and some extracts from his testimony follow:

"I know hundreds of English engineers who have drifted necessarily into the metric system and the decimal system, and I have never heard one who would come back to the English weights and measures if they had the option. In numberless cases it is so much easier. You have only got to remember the specific gravity of different substances and you get all you want readily without short cuts, whether it is iron, or brick, or other material." (From answer No. 2625.)

"I quite agree with the honorable chairman that those short

cuts are rather an evidence of the inconvenience of the present system; if it is worth taking the trouble to get those coincindences and to search for them. And none of Sir Frederick Bramwell's were quite right, although they are nearly." (From answer No. 2647.)

"2648. And you do not want a short cut when you have a straight road? ——— No."

Those so-called "short cuts" are like other approximations that may be found between metric values and different physical constants. The pressure of the atmosphere, stated above to be 1.0333 kilos on a square centimeter, is obviously very near to 1 kilo per square centimeter and in mental calculation may often be taken with sufficient accuracy at that round figure. The length of the second's pendulum is just about one meter, and the acceleration of gravity per second is just about 10 meters, both values varying slightly with latitude and elevation. The townships of the United States public land system are nearly a square myriameter. A common brick is about ten centimeters wide by twenty long. A gram of gold coin is worth 60 cents. That these statements are easier to remember than figures precisely correct is a fact which is not worth very long talking about.

NOTE.

The Textile Industries.—To secure an expression of opinion from the textile industries upon the introduction of the metric system of weights and measures into the United States as proposed by bill H. R. 2,054, reported favorably last winter to the House of Representatives, the editor of the *Textile World* addressed the following questions to a number of the prominent manufacturers throughout the country:

First, Do you favor the immediate adoption of the measure?

Second, Do you oppose it?

Third, Do you favor delaying action until the subject has been calmly and scientifically investigated as in 1817 and in 1866?

Out of 47 replies, which represent the cotton and woolen industries in every section of the United States, 18 favored the metric system, 17 opposed it; 16 did not care for renewal of investigation, while 15 did; others were undecided. Several firms declared themselves as emphatically in favor of the immediate adoption of the system.

R. P. W.

amount of unnecessary work done by quantity
building trades, when taking out quantities,
the Continent all dimensions are in metres, an
tiplications give at once all quantities in square

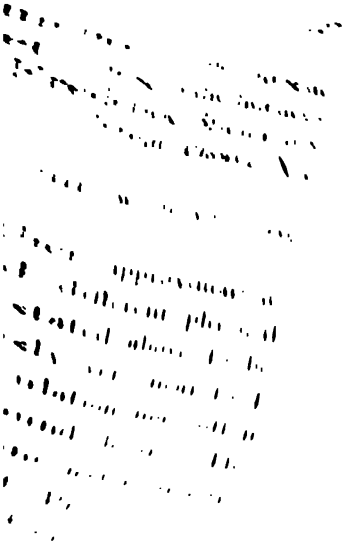
"In the metric system the mean pressure
at sea-level is almost exactly equal to 760 m
cury, which is equal to a column of water 10.33
1.0333 kilogrammes per square centimetre. Sli
as the pressure of coal gas, or the vacuum in
are expressed in millimetres of water, of whic
to an atmosphere, or by kilogrammes per squa
again, there are 10,333 to an atmosphere. T
readily interchangeable without any calculation
the fact that a tube 10 metres high, with a
centimetre, will contain exactly 1 litre of wate
1 kilogramme, and the pressure exerted by the
against its base is, therefore, equal to 1 kilo
centimetre for each 10 metres iiin height."

One way in which the superior simplicity
metric units is manifested is in the assertio
opponents who argue that old weights and
conveniently by the application of ingeni
toward relationship which for various classe
been devised and are remembered by the spe
classes of work. One very eminent man wh
would-be adverse argument was Sir Freder
merly president of the Institution of Civ
Britain. He presented his idea embodie
"Short Cuts," before the special committee
mons which heard a great deal of evidenc

Sir Benjamin Baker, who has also
Institution of Civil Engineers, was exam
wards, and some extracts from his testim

"I know hundreds of English engine
essarily into the metric system and th
have never heard one who would come b
and measures if they had the option.
so much easier. You have only got
gravity of different substances and you
without short cuts, whether it is iron, o
(From answer No. 2625.)

"I quite agree with the honorabl



TEACHERS.

in the biological
., Friday, Decem-
ly thirty members
m Manhattan and

incipal of the Eras-
on "The Relation of
Course." He said, in
work should be em-
implements should be
The age factor is an
one great auxiliary use
glish.

others, all teachers of
the points Dr. Gunnison
d, many points of value
iews.

ig was the social meeting
nts were served by a local
ared and demonstrated by
to show what could be done
tudents. A number of well
exhibited, the work of the
ne informal meeting adjourned

W. HUNTER, JR., SECRETARY.

F CHEMISTRY TEACHERS.

November 15, 1902. The morning
fternoon the members met in the
building for business and to listen

lizabeth Clark, of Monson (Mass.)
mber, and Professor A. A. Noyes, of
chnology, was elected an honorary
re elected for the ensuing year:
hool, president.
h School, vice-president.
ligh School, secretary.
igh School, treasurer.
glish High School; Miss L. P Patten,

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

BOTANY.

Nuclei in Spirogyra can be very much better seen in specimens kept in a well shaded place. In about a week they become very distinct in species, in which the cells contain two or more chloroplasts.

Hope College. S. O. MAST.

"*A vast botanical garden* is one of Dr. Engler's latest conceptions," says Dr. H. C. Cowles, in the October "Botanical Gazette." Such a garden is to display characteristic plant formations of the world; and for the sake of illustration, North America (north of Mexico) is divided into four main floristic divisions, recognizing that the great cleavage lines in the United States run north and south. This is of interest, because students in the last ten years have endeavored to make these lines run east and west. In general, the outlines are true, and, though given to indicate plans for a garden in Europe, the paper is an important contribution to American Phytogeography.

Detroit Central High School. BERNICE L. HAUG.

The production of tuberous or leafy shoots in Marjolin, a French variety of potato tuber, seems to be a matter of temperature and moisture, according to an abstract in the September *Botanical Gazette,* the tuberous shoots being due to low temperature and dryness and the leafy shoots to the opposite conditions. Leafy shoots started at high temperature, changed from negative to positively geotropic conditions, when subjected to lower temperature. The morphology and position of the tuberous shoot, then, seems to be due to temperature and moisture conditions. Miss Newell in her "Outlines of Lessons in Botany," I, p. 51, gives a similar experiment in the common potato, without assigning causes.

That the sensitive plant is a weed in any country is just as interesting to many as to learn that many of our weeds were once cultivated plants introduced from Europe. In the September number of the *Botanical Gazette,* Dr. David Fairchild of Washington gives a photograph of a field in Columbia showing *Mimosa pudica* in profusion. He says of it, "The cattle in the field had eaten the herbage close around the plant, leaving it strictly alone, and as it crept across the meadow it killed out all other plants." * * * One would think that the plant under these circumstances would be less sensitive, but the writer tells that the plants within the radius of the ground shaken by footfall went into the characteristic position of rest, and where the embankments of the railway were covered with *Mimosa,* the quick falling of the leaves with the advance of the train furnished an interesting and amusing sight.

L. M.

Reports of Meetings.

THE NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

The second meeting of the academic year was held in the biological laboratory of the Boys' High School, Brooklyn, at 9 p. m., Friday, December 12, 1902. In spite of the very inclement night, nearly thirty members of the association were present, including several from Manhattan and the Bronx.

The speaker of the evening was Dr. Gunnison, principal of the Erasmus Hall High School, who addressed the meeting on "The Relation of the Sciences to the Humanities in the High School Course." He said, in part, that in his belief the nature study side of the work should be emphasized; that fewer instruments and laboratory implements should be used, and that the work should be less scientific. The age factor is an important one and is far from being solved. The one great auxiliary use of biology was in connection with writing and English.

The speaker was followed by a number of others, all teachers of of biology, who differed decidedly with some of the points Dr. Gunnison made. In the informal discussion that followed, many points of value were brought out for the supporters of both views.

Not the least enjoyable part of the evening was the social meeting after the business meeting, at which refreshments were served by a local caterer. A series of microscopic slides, prepared and demonstrated by Mr. Lewis, of the Boys' High School, served to show what could be done with the microscope in the case of older students. A number of well prepared demonstration specimens was also exhibited, the work of the teaching corps of the Boys' High School. The informal meeting adjourned about 11 p. m., to meet January 30th, 1903.

G. W. Hunter, Jr., Secretary.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The fifteenth meeting was held on November 15, 1902. The morning was devoted to excursions, and in the afternoon the members met in the new Dorchester (Mass.) High School building for business and to listen to an address.

At the business meeting, Miss Elizabeth Clark, of Monson (Mass.) Academy, was elected an associate member, and Professor A. A. Noyes, of the Massachusetts Institute of Technology, was elected an honorary member. The following officers were elected for the ensuing year:

L. G. Smith, Roxbury High School, president.

A. S. Perkins, Dorchester High School, vice-president.

G. A. Cowen, W. Roxbury High School, secretary.

E. F. Holden, Charlestown High School, treasurer.

G. W. Earle, Somerville English High School; Miss L. P. Patten,

Medford High School; O. P. Watts, Waltham High School, additional members of executive committee.

About thirty members visited the New England Gas & Coke Company and the United States Steel Company at Everett, Mass. They were courteously conducted through each plant by officials. The following is a resumé of the visit:

The plant of the New England Gas & Coke Company was built in 1898. It has 400 Otto-Hoffmann ovens that will carbonize 1,650 long tons of coal per 24 hours. This amount of coal produces 1,400 tons of coke and 16,500,000 cubic feet of gas, about 7,000,000 cubic feet of which is for the market. The remainder of the gas heats the ovens. The yield per day of tar is 5 per cent, 82 tons by weight; of ammonium sulphate, about 1 per cent, 16 tons.

The coal is taken from the docks and carried to the bins by cable cars. The bins, holding two days' supply, are between two sections of the ovens. The coal is carried from the bins by a larry, which runs on a track over the ovens, and consists of a narrow bin with eight spouts in the bottom, through which the coal is emptied into the retorts.

The oven or retort is an air-tight chamber, 43.5 feet long, 17 inches wide and 6.5 feet high. The temperature of the oven is about 1,100° C. This temperature is obtained by burning part of the gas made at the plant. The gas does not unite with cold air, but with air that has been heated to 1,000° C. in what is called a regenerator. There are two regenerators for each set of retorts. They are used alternately, being changed every half hour. The time necessary to carbonize a charge is 24 hours.

There are two gas mains, one for carrying the rich gas which comes off first, the other for the poor gas used in the plant for heating. A ton of coal will produce 9,000 cubic feet of gas; 4,000 cubic feet are sent to the city, 5,000 cubic feet are used to heat the ovens.

When the carbonizing is complete, both mains are closed and the glowing coke is pushed out upon a platform by a ram, quenched with water and allowed to cool.

Both the rich and poor gas pass through an air cooler and several multitubular water coolers, then through exhausters and ammonia washers. Here the good and the bad part company; the good goes to the purifying plant, the bad, after being freed of its benzol, to the tank that supplies the furnace. The benzol is used later to increase the candle power of the rich gas.

At the purifying plant there are eight lime purifiers, seven of which are in use at one time, and four ferric oxide purifiers, of which three are used at one time; 7.5 pounds of lime are used per 1,000 cubic feet of gas. The ferric oxide purifiers are revivified about five times a month.

The gas furnished is from 18 to 20 candle power.

Of the 1,400 tons of coke made each day, 700 tons are sold for locomotive fuel, 350 tons to steam plants, 350 tons for domestic fuel.

The tar upon distillation gives light oils to 200° C., aniline benzol, solvent naphtha, creosote oil, crude naphthalene, anthracene oil, pure anthracene and pitch.

A ton of coal furnishes about 8 pounds of ammonia. As said before, this is converted into ammonium sulphate before it is put upon the market.

The United States Steel Company is making a high-grade steel from cheap, raw material. Old boiler plates, broken crank shafts, scrap steel of any kind, are broken up and melted for smaller castings in fire-clay crucibles; for the larger in a Siemens' open hearth furnace.

The process in brief is as follows: 100 pounds of scrap steel are melted and raised to its boiling point, 2,200°C, and from 1.5 to 2.5 pounds of ferro-silicon, containing 12 per cent of silicon, are then introduced. When this is melted, from 2 to 8 ounces of ferro-manganese, containing 80 per cent of manganese, are added. When these ingredients are thoroughly combined, the steel is ready for pouring. The figures given show the proportions only. The capacity of the furnace is 25 tons.

The steel is excellent in strength and temper, no forging, tempering or annealing being necessary. Cold chisels and hatchets can be cast and finished to shape.

Great care is taken in making the moulds. The sand used comes from New Jersey, and the clay from Martha's Vineyard. The moulds are baked before being filled with molten steel.

Gas fuel is used in the furnaces, and the gas, which must be free from sulphur, is made on the premises.

Large castings are made here, such as rams for battleships. During the visit the members saw the completion of the large mould of part of a disappearing gun carriage.

All the operations except the pouring were seen by the members.

The address of Professor A. A. Noyes was on "The Interpretation of the Usual Scheme of Qualitative Analysis by the Help of the Ionic Theory and the Mass Action Law." The speaker discussed the main features of the ionic theory and the law of mass action, illustrated them by experiments, and applied the chief principles to the qualitative groups. The address was clear, accurate, interesting and helpful.

Mr. Charles R. Allen, chairman of the committee on laboratory construction, made an informal report on the progress of the work. From replies to a series of questions, the following is a consensus of opinion regarding the construction of a laboratory:

The total cost of material consumed per pupil is about $1.50, the divisions could not exceed 18, and the majority were of the opinion that, where there was but one course in each subject, physics should precede chemistry, though a better arrangement was suggested in the order, elementary physics, chemistry, advanced physics.

Desks should be arranged in blocks, back to back, taking from four to twelve students, with the light coming from the end, with aisles at least five feet wide between. The floor should be so constructed that it can be sluiced down, and cement or asphalt, tile, wood and linoleum were recommended in the order given. The ventilation should be something more than the gravity system, and there should be some special form of extra draught for the laboratory, even when power ventilation is used, this to be under the control of the teacher. An electric fan has been very generally suggested.

The laboratory should contain hoods in blocks at the sides, in the proportion of about one to four students. These should be provided with an extra exhaust, under control, as much glass as possible, with a sash front, with catch (not weights), a vitreous floor, all provided with gas, and some with a sink, and any other accessories that are provided at the desks. The flues should be of terra cotta or of copper, not iron.

Side reagents; the more common ones on shelves at points easily accessible to groups of not over ten, the less common ones in one or more cabinets along the side of the wall, these cabinets to have glass fronts and locks.

Distilled water is needed. A still is sufficient, though, if steam is

available *all the time,* that can be directly condensed. In either case, it should be kept in a tank with a spring tap, accessible to all.

The gas supply should be on an independent main from the place where the street service enters the building, with a cut-off at the laboratory, or better in the office; at all events, where only the teacher has access to it. Piping should be so large that full pressure will be maintained when all burners are going at once. There should be two cocks per student, with some extras, and the corrugated form of pillar cock should be used. Naphtha gas and acetylene may be used as substitutes, and there are some forms of oil burners that will do good work.

The provision for artificial light should consist of one good light, preferably electric, over each desk, and it should be possible to adjust the height at will.

Some sort of scales are required; for ordinary work those sensitive to 0.01 grm. are sufficient (horn pan, surgeon's army balance), while at least one accurate set should be provided (to 0.001 grm.). Where delicate balances are used, some form of weighing room is a necessity.

Evaporation can be carried on mainly at the desks with no special appliances. Asbestos mats and iron plates are convenient aids. At other points in the laboratory, steam or water baths are generally recommended, but no special evaporating devices are recommended for the hoods.

No special instructor's desk is needed in a laboratory if there be a lecture room; if not, it should be equipped as the other desks.

The water supply should be on an independent main with cut-off, as in case of gas. It should be large enough to maintain full pressure when all the taps are running. If this is not possible, the service pipe should feed into a pipe in the attic, which should give the laboratory supply.

The laboratory should be situated where no odor can annoy the rest of the school. When this can be done, it should be where the greatest number of pupils can get to it most easily. With ordinary ventilating systems, experience indicates that it is safest to place the chemical laboratory either in a wing or on the top floor.

Under all circumstances it should be adjacent to the lecture room, near the physical laboratory, and the teacher should have a private room, large enough to work in, adjacent to the laboratory, which can also be used in case of accident. A small reference library should be kept in the laboratory or office, and if this is done, the location of the general school library is immaterial.

The scientific plant should include a dark room, but it need not be directly adjacent to the chemical laboratory.

The desks should be provided with gas and water; electric taps, either at the desks or at side tables, are frequently recommended; hydric sulphide should be delivered in the hoods only, and nothing else is needed. Compressed air and vacuum are not generally objected to, but it is doubtful how far the additional complexity of the plant warrants their existence in a secondary school.

No satisfactory data could be obtained as to the area of the desks; about six square feet per student seems to be the general idea; the tops of the desks should not be of wood (tile, soapstone, opalite, glass and slate were recommended in order); water supply, with a spring cock and goose neck, with a pillar cock for attaching rubber tubing. The desks should contain sinks in the ratio of one to two students, and these sinks should be of vitreous material, with rounded corners.

The shelving should be a little wider than the bottles used, either of glass with enameled steel supports, or of wood, covered with plate glass. Wood alone is generally condemned.

The drainage should be so that a straight rod can be pushed to all

parts of it, as much of it vitreous as possible, with a collecting tank between it and sewer trap. As second choice, iron is frequently recommended rather than lead; the latter, if used, should be extra heavy.

Desks should be provided with locks, either combination or master key; any number of students may use one desk in rotation, but each should have entire use of two drawers and a cupboard. The cupboard should have shelves for reagents and hooks on the sides.

In small schools the material may be distributed by the teacher, but with large classes some form of assistance is needed, and some kind of stock room adjacent to the laboratory. A method of giving apparatus under such conditions that the student can be held responsible for its care is recommended.

Reported by LYMAN C. NEWELL.

THE CENTRAL ASSOCIATION OF PHYSICS TEACHERS.

The first regular meeting of the association was held at the Lewis Institute, Chicago, Ill., November 28, 1902, about 200 members and friends being in attendance.

The president, Mr. Charles H. Smith, of the Hyde Park (Chicago) High School, called the meeting to order at 10:30 a. m., and made the following remarks:

It is very pleasing, yes, gratifying, to be able to welcome so many who are directly interested in physics to this conference, which is virtually the first meeting of the Central Association of Physics Teachers. Your presence here is a practical guarantee of the success of this movement. Perhaps it is not out of place at this time to disclose why this conference has been called and what ends are expected to be accomplished. A little history may enable us to better understand it. For a number of years it has been the belief of many physics teachers that great good might be brought about and better results obtained by our pupils and those interested in the subject, if the instructors could come together once or twice a year to exchange ideas and discuss live and practical questions bearing directly upon our work. Last spring, after considering the responses to several hundred letters sent to the physics instructors in all of the cities and larger towns of the northern central portions of our country, it was decided to call a meeting (in June of this year) of those who replied to this initial letter, to discuss plans for an association, if it were deemed feasible. At this meeting, all attending were heartily in favor of such an organization. The result was the adoption of a constitution, in accordance to which we are assembled here today as the Central Association of Physics Teachers.

It may not be out of place for me, at the beginning of this conference, to make some suggestions as to the nature of the work, which we, as an association, can, with much profit, undertake and accomplish. Many ideas have come to me, which I will not attempt to present in any order of sequence. Possibly some of them may be work for an ideal rather than

Metrology.*

SYSTEM IN METRIC WEIGHTS AND MEASURES.

(*Concluded from page 413.*)

A practical illustration of the importance attached to correspondence between different kinds of measures is found in the measure used by mariners of one second of arc on the earth's surface. Why should this be called a (nautical) *mile?* Simply because the real mile used for measurement on land is but a little shorter. It really causes confusion between the measurement established on land and at sea, and sometimes serious mistakes.

But the people of the United States have thought that it was convenient to have the minutes of an arc called a mile, even in spite of its lack of exactness. Their Public Land System, by the way, lays out townships by meridians and parallels run astronomically.

Even if the different systems above outlined had been more complete, their use in combination with one another would have been inconvenient from their conflicting. What is wanted is to have the same arithmetical progression in large as well as small denominations of any one kind of measure, in multiples as well as in subdivision; also to have the same arithmetical system in all kinds of measure; also to have the units of measure of different kinds related to one another. It is this completeness of system which makes the metric weights and measures so very much more convenient than the grotesque confusion of fragments of various systems long customary in the United States. The metric system affords a much better mental grasp of magnitudes and their relations to one another, and is much easier to learn and remember. This has been tersely stated in some leading articles of *Engineering* (London) from which the following sentences are quoted:

"No one can be so dense as not to be able to understand its main features in two minutes. In the decimetre—any other name would do as well or better—we have a convenient standard of

* Communications for the Department of Metrology should be sent to Rufus P Williams, North Cambridge, Mass.

length. A cube of this dimension furnishes the unit of capacity, the litre, while the weight of a litre of water is the unit of weight, the kilogramme. That is the whole of the metric system, and it passes the wit of man to devise one simpler or more convenient." (Vol. 67, p. 519, April 21, 1899).

"Its grand features are that it is based on a single unit both for measures of length, measures of weight, and measures of quantity, and that it admits only one divisor. The gain implied in these two propositions is so immense as to completely overshadow all the criticism that can be brought to bear on its less satisfactory features." (Vol. 61, pp. 509-10, April 17, 1896.)

The convenience resulting from this systematic quality in the practical application of the metric units to various kinds of work was pointed out in an excellent paper on the Metric System of Weights and Measures, read by A. Hanssen before the Civil and Mechanical Engineers' Society and printed in *Engineering* (London), v. 67, pp. 295-6 (March 3, 1899); from it a few quotations may be made:

"Take, for instance, a substance like cast iron, the weight of which we constantly have to calculate from the volumes shown on drawings or described in specifications. Its average specific gravity is 7.23, that is to say, it weighs 7.23 times more than an equal volume of distilled water. This single figure tells us at once that a cubic centimetre weighs 7.23 grammes, a cubic decimetre weighs 7.23 kilogrammes, and a cubic metre weighs 7.23 tonnes. A plate 1 square metre in area and 1 millimetre thick has a volume of 1 cubic decimetre, and it is therefore easily remembered that sheets of cast iron weigh 7.23 kilogrammes per square metre for each millimetre in thickness. If we have a given weight of cast iron, and want to know what volume it occupies, we only have to divide the weight by this one magic factor of 7.23. To convert the grammes and kilogrammes into tonnes it is necessary to insert the usual comma for every three figures of the result."

"With the metric system the quantity of water to be lifted is given in litres or cubic decimetres per second, the speed of the piston is given in decimetres per second, and a division of the first figure by the second gives the area of the pump in square decimetres. The diameter is found from this in decimetres, and we have only to move the decimal point to make them into millimetres."

"This reduction of work by using the metric system, holds good for most calculations made by engineers and architects. The

amount of unnecessary work done by quantity surveyors for the building trades, when taking out quantities, is immense. On the Continent all dimensions are in metres, and one or two multiplications give at once all quantities in squares or cubic metres."

"In the metric system the mean pressure of the atmosphere at sea-level is almost exactly equal to 760 millimetres of mercury, which is equal to a column of water 10.333 metres high or to 1.0333 kilogrammes per square centimetre. Slight pressures, such as the pressure of coal gas, or the vacuum in a chimney stack, are expressed in millimetres of water, of which 10,333 are equal to an atmosphere, or by kilogrammes per square metre, of which, again, there are 10,333 to an atmosphere. These measures are readily interchangeable without any calculation, and depend upon the fact that a tube 10 metres high, with a sectional area of 1 centimetre, will contain exactly 1 litre of water, which will weigh 1 kilogramme, and the pressure exerted by the water in the tube against its base is, therefore, equal to 1 kilogramme per square centimetre for each 10 metres iiin height."

One way in which the superior simplicity of relations among metric units is manifested is in the assertions put forward by opponents who argue that old weights and measures are used conveniently by the application of ingenious approximations toward relationship which for various classes of calculation have been devised and are remembered by the special workers in those classes of work. One very eminent man who has emphasized this would-be adverse argument was Sir Frederick J. Bramwell, formerly president of the Institution of Civil Engineers of Great Britain. He presented his idea embodied in which he called "Short Cuts," before the special committee of the House of Commons which heard a great deal of evidence in 1895.

Sir Benjamin Baker, who has also been president of the Institution of Civil Engineers, was examined immediately afterwards, and some extracts from his testimony follow:

"I know hundreds of English engineers who have drifted necessarily into the metric system and the decimal system, and I have never heard one who would come back to the English weights and measures if they had the option. In numberless cases it is so much easier. You have only got to remember the specific gravity of different substances and you get all you want readily without short cuts, whether it is iron, or brick, or other material." (From answer No. 2625.)

"I quite agree with the honorable chairman that those short

cuts are rather an evidence of the inconvenience of the present system; if it is worth taking the trouble to get those coincindences and to search for them. And none of Sir Frederick Bramwell's were quite right, although they are nearly." (From answer No. 2647.)

"2648. And you do not want a short cut when you have a straight road? ——— No."

Those so-called "short cuts" are like other approximations that may be found between metric values and different physical constants. The pressure of the atmosphere, stated above to be 1.0333 kilos on a square centimeter, is obviously very near to 1 kilo per square centimeter and in mental calculation may often be taken with sufficient accuracy at that round figure. The length of the second's pendulum is just about one meter, and the acceleration of gravity per second is just about 10 meters, both values varying slightly with latitude and elevation. The townships of the United States public land system are nearly a square myriameter. A common brick is about ten centimeters wide by twenty long. A gram of gold coin is worth 60 cents. That these statements are easier to remember than figures precisely correct is a fact which is not worth very long talking about.

NOTE.

The Textile Industries.—To secure an expression of opinion from the textile industries upon the introduction of the metric system of weights and measures into the United States as proposed by bill H. R. 2,054, reported favorably last winter to the House of Representatives, the editor of the *Textile World* addressed the following questions to a number of the prominent manufacturers throughout the country:

First, Do you favor the immediate adoption of the measure?

Second, Do you oppose it?

Third, Do you favor delaying action until the subject has been calmly and scientifically investigated as in 1817 and in 1866?

Out of 47 replies, which represent the cotton and woolen industries in every section of the United States, 18 favored the metric system, 17 opposed it; 16 did not care for renewal of investigation, while 15 did; others were undecided. Several firms declared themselves as emphatically in favor of the immediate adoption of the system.

R. P. W.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

BOTANY.

Nuclei in Spirogyra can be very much better seen in specimens kept in a well shaded place. In about a week they become very distinct in species, in which the cells contain two or more chloroplasts.

Hope College. S. O. MAST.

"*A vast botanical garden* is one of Dr. Engler's latest conceptions," says Dr. H. C. Cowles, in the October "Botanical Gazette." Such a garden is to display characteristic plant formations of the world; and for the sake of illustration, North America (north of Mexico) is divided into four main floristic divisions, recognizing that the great cleavage lines in the United States run north and south. This is of interest, because students in the last ten years have endeavored to make these lines run east and west. In general, the outlines are true, and, though given to indicate plans for a garden in Europe, the paper is an important contribution to American Phytogeography.

Detroit Central High School. BERNICE L HAUG.

The production of tuberous or leafy shoots in Marjolin, a French variety of potato tuber, seems to be a matter of temperature and moisture, according to an abstract in the September *Botanical Gazette,* the tuberous shoots being due to low temperature and dryness and the leafy shoots to the opposite conditions. Leafy shoots started at high temperature, changed from negative to positively geotropic conditions, when subjected to lower temperature. The morphology and position of the tuberous shoot, then, seems to be due to temperature and moisture conditions. Miss Newell in her "Outlines of Lessons in Botany," I, p. 51, gives a similar experiment in the common potato, without assigning causes.

That the sensitive plant is a weed in any country is just as interesting to many as to learn that many of our weeds were once cultivated plants introduced from Europe. In the September number of the *Botanical Gazette,* Dr. David Fairchild of Washington gives a photograph of a field in Columbia showing *Mimosa pudica* in profusion. He says of it, "The cattle in the field had eaten the herbage close around the plant, leaving it strictly alone, and as it crept across the meadow it killed out all other plants." * * * One would think that the plant under these circumstances would be less sensitive, but the writer tells that the plants within the radius of the ground shaken by footfall went into the characteristic position of rest, and where the embankments of the railway were covered with *Mimosa,* the quick falling of the leaves with the advance of the train furnished an interesting and amusing sight.

L. M.

Reports of Meetings.

THE NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

The second meeting of the academic year was held in the biological laboratory of the Boys' High School, Brooklyn, at 9 p. m., Friday, December 12, 1902. In spite of the very inclement night, nearly thirty members of the association were present, including several from Manhattan and the Bronx.

The speaker of the evening was Dr. Gunnison, principal of the Erasmus Hall High School, who addressed the meeting on "The Relation of the Sciences to the Humanities in the High School Course." He said, in part, that in his belief the nature study side of the work should be emphasized; that fewer instruments and laboratory implements should be used, and that the work should be less scientific. The age factor is an important one and is far from being solved. The one great auxiliary use of biology was in connection with writing and English.

The speaker was followed by a number of others, all teachers of of biology, who differed decidedly with some of the points Dr. Gunnison made. In the informal discussion that followed, many points of value were brought out for the supporters of both views.

Not the least enjoyable part of the evening was the social meeting after the business meeting, at which refreshments were served by a local caterer. A series of microscopic slides, prepared and demonstrated by Mr. Lewis, of the Boys' High School, served to show what could be done with the microscope in the case of older students. A number of well prepared demonstration specimens was also exhibited, the work of the teaching corps of the Boys' High School. The informal meeting adjourned about 11 p. m., to meet January 30th, 1903.

G. W. Hunter, Jr., Secretary.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The fifteenth meeting was held on November 15, 1902. The morning was devoted to excursions, and in the afternoon the members met in the new Dorchester (Mass.) High School building for business and to listen to an address.

At the business meeting, Miss Elizabeth Clark, of Monson (Mass.) Academy, was elected an associate member, and Professor A. A. Noyes, of the Massachusetts Institute of Technology, was elected an honorary member. The following officers were elected for the ensuing year:

L. G. Smith, Roxbury High School, president.

A. S. Perkins, Dorchester High School, vice-president.

G. A. Cowen, W. Roxbury High School, secretary.

E. F. Holden, Charlestown High School, treasurer.

G. W. Earle, Somerville English High School; Miss L. P. Patten,

Medford High School; O. P. Watts, Waltham High School, additional members of executive committee.

About thirty members visited the New England Gas & Coke Company and the United States Steel Company at Everett, Mass. They were courteously conducted through each plant by officials. The following is a resumé of the visit:

The plant of the New England Gas & Coke Company was built in 1898. It has 400 Otto-Hoffmann ovens that will carbonize 1,650 long tons of coal per 24 hours. This amount of coal produces 1,400 tons of coke and 16,500,000 cubic feet of gas, about 7,000,000 cubic feet of which is for the market. The remainder of the gas heats the ovens. The yield per day of tar is 5 per cent, 82 tons by weight; of ammonium sulphate, about 1 per cent, 16 tons.

The coal is taken from the docks and carried to the bins by cable cars. The bins, holding two days' supply, are between two sections of the ovens. The coal is carried from the bins by a larry, which runs on a track over the ovens, and consists of a narrow bin with eight spouts in the bottom, through which the coal is emptied into the retorts.

The oven or retort is an air-tight chamber, 43.5 feet long, 17 inches wide and 6.5 feet high. The temperature of the oven is about 1,100° C. This temperature is obtained by burning part of the gas made at the plant. The gas does not unite with cold air, but with air that has been heated to 1,000° C. in what is called a regenerator. There are two regenerators for each set of retorts. They are used alternately, being changed every half hour. The time necessary to carbonize a charge is 24 hours.

There are two gas mains, one for carrying the rich gas which comes off first, the other for the poor gas used in the plant for heating. A ton of coal will produce 9,000 cubic feet of gas; 4,000 cubic feet are sent to the city, 5,000 cubic feet are used to heat the ovens.

When the carbonizing is complete, both mains are closed and the glowing coke is pushed out upon a platform by a ram, quenched with water and allowed to cool.

Both the rich and poor gas pass through an air cooler and several multitubular water coolers, then through exhausters and ammonia washers. Here the good and the bad part company; the good goes to the purifying plant, the bad, after being freed of its benzol, to the tank that supplies the furnace. The benzol is used later to increase the candle power of the rich gas.

At the purifying plant there are eight lime purifiers, seven of which are in use at one time, and four ferric oxide purifiers, of which three are used at one time; 7.5 pounds of lime are used per 1,000 cubic feet of gas. The ferric oxide purifiers are revivified about five times a month.

The gas furnished is from 18 to 20 candle power.

Of the 1,400 tons of coke made each day, 700 tons are sold for locomotive fuel, 350 tons to steam plants, 350 tons for domestic fuel.

The tar upon distillation gives light oils to 200° C., aniline benzol, solvent naphtha, creosote oil, crude naphthalene, anthracene oil, pure anthracene and pitch.

A ton of coal furnishes about 8 pounds of ammonia. As said before, this is converted into ammonium sulphate before it is put upon the market.

The United States Steel Company is making a high-grade steel from cheap, raw material. Old boiler plates, broken crank shafts, scrap steel of any kind, are broken up and melted for smaller castings in fire-clay crucibles; for the larger in a Siemens' open hearth furnace.

The process in brief is as follows: 100 pounds of scrap steel are melted and raised to its boiling point, 2,200°C., and from 1.5 to 2.5 pounds of ferro-silicon, containing 12 per cent of silicon, are then introduced. When this is melted, from 2 to 8 ounces of ferro-manganese, containing 80 per cent of manganese, are added. When these ingredients are thoroughly combined, the steel is ready for pouring. The figures given show the proportions only. The capacity of the furnace is 25 tons.

The steel is excellent in strength and temper, no forging, tempering or annealing being necessary. Cold chisels and hatchets can be cast and finished to shape.

Great care is taken in making the moulds. The sand used comes from New Jersey, and the clay from Martha's Vineyard. The moulds are baked before being filled with molten steel.

Gas fuel is used in the furnaces, and the gas, which must be free from sulphur, is made on the premises.

Large castings are made here, such as rams for battleships. During the visit the members saw the completion of the large mould of part of a disappearing gun carriage.

All the operations except the pouring were seen by the members.

The address of Professor A. A. Noyes was on "The Interpretation of the Usual Scheme of Qualitative Analysis by the Help of the Ionic Theory and the Mass Action Law." The speaker discussed the main features of the ionic theory and the law of mass action, illustrated them by experiments, and applied the chief principles to the qualitative groups. The address was clear, accurate, interesting and helpful.

Mr. Charles R. Allen, chairman of the committee on laboratory construction, made an informal report on the progress of the work. From replies to a series of questions, the following is a consensus of opinion regarding the construction of a laboratory:

The total cost of material consumed per pupil is about $1.50, the divisions could not exceed 18, and the majority were of the opinion that, where there was but one course in each subject, physics should precede chemistry, though a better arrangement was suggested in the order, elementary physics, chemistry, advanced physics.

Desks should be arranged in blocks, back to back, taking from four to twelve students, with the light coming from the end, with aisles at least five feet wide between. The floor should be so constructed that it can be sluiced down, and cement or asphalt, tile, wood and linoleum were recommended in the order given. The ventilation should be something more than the gravity system, and there should be some special form of extra draught for the laboratory, even when power ventilation is used, this to be under the control of the teacher. An electric fan has been very generally suggested.

The laboratory should contain hoods in blocks at the sides, in the proportion of about one to four students. These should be provided with an extra exhaust, under control, as much glass as possible, with a sash front, with catch (not weights), a vitreous floor, all provided with gas, and some with a sink, and any other accessories that are provided at the desks. The flues should be of terra cotta or of copper, not iron.

Side reagents; the more common ones on shelves at points easily accessible to groups of not over ten, the less common ones in one or more cabinets along the side of the wall, these cabinets to have glass fronts and locks.

Distilled water is needed. A still is sufficient, though, if steam is

available *all the time,* that can be directly condensed. In either case, it should be kept in a tank with a spring tap, accessible to all.

The gas supply should be on an independent main from the place where the street service enters the building, with a cut-off at the laboratory, or better in the office; at all events, where only the teacher has access to it. Piping should be so large that full pressure will be maintained when all burners are going at once. There should be two cocks per student, with some extras, and the corrugated form of pillar cock should be used. Naphtha gas and acetylene may be used as substitutes, and there are some forms of oil burners that will do good work.

The provision for artificial light should consist of one good light, preferably electric, over each desk, and it should be possible to adjust the height at will.

Some sort of scales are required; for ordinary work those sensitive to 0.01 grm. are sufficient (horn pan, surgeon's army balance), while at least one accurate set should be provided (to 0.001 grm.). Where delicate balances are used, some form of weighing room is a necessity.

Evaporation can be carried on mainly at the desks with no special appliances. Asbestos mats and iron plates are convenient aids. At other points in the laboratory, steam or water baths are generally recommended, but no special evaporating devices are recommended for the hoods.

No special instructor's desk is needed in a laboratory if there be a lecture room; if not, it should be equipped as the other desks.

The water supply should be on an independent main with cut-off, as in case of gas. It should be large enough to maintain full pressure when all the taps are running. If this is not possible, the service pipe should feed into a pipe in the attic, which should give the laboratory supply.

The laboratory should be situated where no odor can annoy the rest of the school. When this can be done, it should be where the greatest number of pupils can get to it most easily. With ordinary ventilating systems, experience indicates that it is safest to place the chemical laboratory either in a wing or on the top floor.

Under all circumstances it should be adjacent to the lecture room, near the physical laboratory, and the teacher should have a private room, large enough to work in, adjacent to the laboratory, which can also be used in case of accident. A small reference library should be kept in the laboratory or office, and if this is done, the location of the general school library is immaterial.

The scientific plant should include a dark room, but it need not be directly adjacent to the chemical laboratory.

The desks should be provided with gas and water; electric taps, either at the desks or at side tables, are frequently recommended; hydric sulphide should be delivered in the hoods only, and nothing else is needed. Compressed air and vacuum are not generally objected to, but it is doubtful how far the additional complexity of the plant warrants their existence in a secondary school.

No satisfactory data could be obtained as to the area of the desks; about six square feet per student seems to be the general idea; the tops of the desks should not be of wood (tile, soapstone, opalite, glass and slate were recommended in order); water supply, with a spring cock and goose neck, with a pillar cock for attaching rubber tubing. The desks should contain sinks in the ratio of one to two students, and these sinks should be of vitreous material, with rounded corners.

The shelving should be a little wider than the bottles used, either of glass with enameled steel supports, or of wood, covered with plate glass. Wood alone is generally condemned.

The drainage should be so that a straight rod can be pushed to all

parts of it, as much of it vitreous as possible, with a collecting tank between it and sewer trap. As second choice, iron is frequently recommended rather than lead; the latter, if used, should be extra heavy.

Desks should be provided with locks, either combination or master key; any number of students may use one desk in rotation, but each should have entire use of two drawers and a cupboard. The cupboard should have shelves for reagents and hooks on the sides.

In small schools the material may be distributed by the teacher, but with large classes some form of assistance is needed, and some kind of stock room adjacent to the laboratory. A method of giving apparatus under such conditions that the student can be held responsible for its care is recommended.

Reported by LYMAN C. NEWELL.

THE CENTRAL ASSOCIATION OF PHYSICS TEACHERS.

The first regular meeting of the association was held at the Lewis Institute, Chicago, Ill., November 28, 1902, about 200 members and friends being in attendance.

The president, Mr. Charles H. Smith, of the Hyde Park (Chicago) High School, called the meeting to order at 10:30 a. m., and made the following remarks:

It is very pleasing, yes, gratifying, to be able to welcome so many who are directly interested in physics to this conference, which is virtually the first meeting of the Central Association of Physics Teachers. Your presence here is a practical guarantee of the success of this movement. Perhaps it is not out of place at this time to disclose why this conference has been called and what ends are expected to be accomplished. A little history may enable us to better understand it. For a number of years it has been the belief of many physics teachers that great good might be brought about and better results obtained by our pupils and those interested in the subject, if the instructors could come together once or twice a year to exchange ideas and discuss live and practical questions bearing directly upon our work. Last spring, after considering the responses to several hundred letters sent to the physics instructors in all of the cities and larger towns of the northern central portions of our country, it was decided to call a meeting (in June of this year) of those who replied to this initial letter, to discuss plans for an association, if it were deemed feasible. At this meeting, all attending were heartily in favor of such an organization. The result was the adoption of a constitution, in accordance to which we are assembled here today as the Central Association of Physics Teachers.

It may not be out of place for me, at the beginning of this conference, to make some suggestions as to the nature of the work, which we, as an association, can, with much profit, undertake and accomplish. Many ideas have come to me, which I will not attempt to present in any order of sequence. Possibly some of them may be work for an ideal rather than

a practical association. Yet the more ideal we become in devising ways, means and methods to help each other and assist in presenting the subject of physics to our pupils, the more nearly practical will the association become.

First in order of the suggestions is that, if this organization is to have any influence and worth, it must be of such a character and standing that it will be necessary for every person teaching physics, whether in a secondary school or college, to become a member in order to maintain any professional standing among his co-laborers. Indeed, the association must be made so strong that no physics teacher of worth can afford not to be a member and helper in it.

In physics there has never been any central body of recognized standing to which boards of education or committees, empowered with authority to make out a school curriculum, could go for information as to the proper branches of physics to be taught and how much time ought to be devoted to the study of each head. Individuals here and there have given this advice, which, while good, has had a result of no uniformity of method in presenting the subject in different schools. This condition ought not to exist; it can be remedied.

This association should assume the responsibility of writing and publishing a thoroughly up-to-date text and manual in physics which will be correlated with algebra, geometry and chemistry in such a manner that the subjects mentioned may be studied with reference to their interdependence upon each other in the class room as well as laboratory. The books, too, should contain nothing but that which is true and capable of being verified by any teacher. They should be composed of the best ideas from all good texts, together with new ideas on the subject not yet published. No hobby of some author or any fancy or showy experiment should enter. The subject matter should be correlated and presented in that manner which will make it possible for all schools where physics is taught to be teaching it in the same order after common methods. We should try to so arrange the matter of physics and the mathematics upon which it depends that the pupil will get the greatest possible knowledge of the subject in the least possible time. We might also use our influence for the better equipment of laboratories, especially in the country towns.

The public should be made to feel more thoroughly the dignity and importance of physics as it appertains to the daily affairs of commercial, social and educational life. Just how this can be brought about, I will not now stop to discuss. In this age the knowledge of physics is almost as essential to a successful career as an understanding of arithmetic. Why does arithmetic receive so much attention in the grades to the exclusion of physics? I am not opposed to the idea that the young grader ought to study his mathematics after a laboratory method along with elementary physics. We must labor for more complete sympathy for science from the grades to the secondary school and on to the college and university.

The secondary school, instead of devoting so much time in instructing a pupil in the exercises required for entrance to college, should be spending the greater part of the time in teaching the pupil physics for common daily life. The association ought to use its influence in consummating this plan. For the boy who does not go to college needs his physics far more than his more fortunate brother.

Another important point for consideration is how to bring the physics teacher and apparatus dealer, whose interests are common, into a better acquaintanceship, and this association should become a bureau of information for teacher and dealer, and should always have the names of the firm from which to purchase the best apparatus and supplies for the least money. Also, her influence should be felt among those apparatus dealers who do not yet understand that the day is past when they can dispose of old-fashioned and cheap grades of apparatus to any school. Instructors, through this organization, should inform the dealer what apparatus he can sell instead of the dealer directing what variety and quality must be purchased. The user ought to be the inventor or designer of new apparatus and the instrument maker the improver of it.

This new-born society should be an investigator of what there is to be taught and what the best method is of presenting it. This can be brought about by general discussion of live topics, as will be done this afternoon, and also by the assistance of each individual teacher, who, when he originates a new scheme, will arrange it for publication, then send it to the secretary, who will have it published and distributed in pamphlet form or else in our official organ, which we must have, and will have if the ideas of the founders of the association are carried out. If anything is said or done in the meetings of this body which is of worth, there must be a method by which all who are anxious to profit by these conferences can do so. Perhaps the editor of SCHOOL SCIENCE can be prevailed upon to make that organ the one through which we can spread the proceedings and investigations of this association to the physics world.

This subject of an official organ presents the idea of a paid secretary. If the organization is what it can be made to be, eventually a paid secretary we must have, to attend to clerical and publishing interests. His duties may be augmented by keeping a list of people who desire positions as physics teachers, and also discovering where vacancies are or are likely to occur. There is no reason why good teachers should not be helped by a body of this kind in this manner as well as in the methods of teaching.

The association, too, must act as a distributor of physics literature, whether it be its own or that written by others. It must strive to stimulate and keep in active working condition all teachers whom it can reach. It must elevate the standard of physics teaching, which must stand on as high a plane as that of any other study. We must compel the brother who is inclined to go to sleep to keep working or else drop out, from the fact that he cannot reach the high standard to be set by this organization.

It would be an excellent thing for the association to determine the

best methods for performing the best and broadest experiments (that is, those experiments out of which the pupil is to get the greatest good). A list of such could be made and placed in the hands of every teacher, or this might be incorporated as a part of the manual of which I have spoken.

Then, too, the individual members must act as a committee of one to become acquainted with every other member. Do we appreciate acquaintanceship enough? We can get help for our personal work by brushing up against one another and exchanging views on this or that question. The conversation at such a meeting as this must necessarily be of the shop. I hope every one here will get acquainted with every one else before the conference is over.

The discussion of practical physics questions will be a great help to each of us. If you have questions you would like to have considered, send them to the secretary. Of course, it will be quite impossible to present them all at a general meeting, but they can be brought up in meetings of the Local Centers and the results reported at the next general meeting.

As to the Local Centers, they ought to be, and I might say they could advantageously be formed in all of the larger cities where instructors interested can get together four or five times a year for purposes heretofore named.

The question of an endowment to meet the expenses, which will surely come if the ideas already mentioned are carried out, is not a bad one. How it is to come is a question. We might have life members constituted by the payment of $50.00. If we could get enough, the question would be solved.

So much for some of the problems in the solution of which we may assist. But if our coming together in this territory is to encourage improvement in all interests centered in such a body, why not make it national in character? Why not invite all societies of kindred nature to unite with us their efforts so that they may all be centered upon one common interest—the better teaching of physics, other sciences and mathematics.

Dr. Henry S. Carhart, professor of physics in the University of Michigan, then delivered an address on "Revision of Physical Theory." This was published on page 371 of the January issue of this journal.

After the address lunch was served in the lunch room of the institute, at the conclusion of which the laboratories and shops of the institute were inspected.

At the beginning of the afternoon session the following communication was read by the secretary and referred to the executive committee:

Many science teachers of the Chicago and other high schools having expressed a desire for the organization of a "Central Association of Science Teachers," a preliminary meeting of teachers of each high school

science was called together by representatives of the Biology Round Table of the Chicago schools, by whom the subject had already been favorably considered.

All present spoke favorably of the need of such an organization and promised to bring it before their respective Round Table meetings. The physics teachers, having already formed a general organization, it was voted to bring the discussion of the advantages and purposes of an organization of *all* science teachers before the "Central Association of Physics Teachers" at their meeting on November 28.

The purpose of a general association of science teachers could be briefly stated as follows:

To promote the better teaching of all sciences in secondary schools, and to obtain the better correlation of the sciences to each other and to the general problem of education.

Some of the advantages of a *general* science association over the separate organization of each science are:

First—In "union there is strength," as shown by the success of the American Association for the advancement of Science, along the lines of which we would organize.

Second.—A larger attendance would be secured and so better railroad rates.

Third.—There would be section meetings for the consideration of subjects pertaining to each science, and general meetings for topics pertaining to the better correlation of the work.

A spring meeting in Chicago could be called for the first of April, when many schools have their spring vacation and Chicago schools are still in session. This would allow of the visiting of the laboratories. The first meeting could be set for Friday afternoon, at which a final organization might be perfected.

Will the Physics Association kindly take action on this communication, and appoint a committee to confer with teachers of the other sciences looking to this preliminary organization?

Mr. Ernest J. Andrews of the Robert A. Waller high school (Chicago) as chairman of the Committee on Current Events, presented the following report:

Mr. President and Fellow Members: Your committee on Current Events respectfully offers for your consideration the following report: We have perhaps taken some liberties with the words "current events," construing them more broadly than is usual. It has seemed best to leave to the ordinary periodicals the announcement of mere events, such as the deaths of scientists, the founding of science schools, or the like, as all such information is at the hand of every active physics teacher. And we have given attention to somewhat minor matters, which are, however, of special interest.

In the first place we find a large number of high schools are build-

ing at the present time; others are finished; and many are contemplated. Boston has recently completed four new buildings, all of the best character. Philadelphia has just dedicated its magnificent high school for boys, costing $1,533,000. Chicago has just completed a fine building and has two others well under way, one of which is to receive the historical name of McKinley. The high schools at Rochester, Omaha, New Haven, Des Moines, Syracuse and others will soon move into new buildings, and many are well under way, to be finished within a year.

This is very gratifying to all high school workers, in view of the fact that forty years ago high schools were fighting for existence, with but forty-five buildings in the United States. Today there are over 6,000, and the number is rapidly growing. But perhaps the most gratifying part is the perfection of the buildings and their equipments. The Philadelphia Central high school for boys, mentioned above, is the largest and finest high school building in the world; it will accommodate 2,400 pupils, and has an assembly hall which will hold 2,500 persons. It has a telescope, with a 15-inch lens, costing $30,000.

And when we come to the provisions which are making for science, and particularly for physics, it causeth the heart of the physics worker to rejoice. The newest Chicago building, perhaps, is typical of the provisions for physics in these new buildings that are springing up. In this building, which is the Robert A. Waller high school, six rooms are devoted to the physics department—the main laboratory, the lecture room, the shop, the dark room, a store room, and a private laboratory for the teacher, each of the rooms being fully sufficient in size and arrangement for the purpose intended. Some of the newer buildings, however, exceed this provision. Cambridge reports a separate laboratory for light and heat, one for mechanics, and one for electricity; New Haven has in the new building about the same

Coming to equipment and apparatus, the new laboratories are improving on the old, and the old ones are constantly replacing old or inferior equipment for something better. The Chicago school mentioned above put in $2,500 for pupils' apparatus, and about twice as much for general equipment. It has a full shop outfit, hot and cold water, steam and gas, with electricity constantly at hand under pressures of 34 different electromotive forces ranging from 500 volts down to one volt, with specially devised switches for giving every desirable combination of cells or of lamp or other resistances, or combination of the various apparatus used, such as voltmeter, ammeter, battery rheostats, and the like, so that no time whatever is lost in making or changing combinations. It has a lecture room which will hold several classes, with optical lantern. This room may be darkened in twelve sections by a switch, which at the same time lowers the screen for use.

Compared with the little corner room with the surprising inhabitants, which some of us enjoyed during our high school days, such gra-

visions seem marvelous. But some schools report even more, in some lines at least. The Central high school of Kansas City now has a shop equipment, a 7½ horse power direct motor, a 15-inch swing lathe, a 9-inch Barnes lathe, a 10-inch wood lathe, a saw bench, a jig saw, an emery grinder, a power grindstone, a polishing buff and a drill press, all of which are used solely for the construction and repair of apparatus. We think our honorable vice-president is to be envied.

All this calls for increased ability on the part of the physics teacher; he must have a thorough theoretical knowledge of the subject, and must be a machinist and electrical engineer scarcely inferior to the professional. In view of this the prerequisites of physics teachers are increasing. But it is not so with the perquisites. Because of the greater ability required, and particularly because of the increased expense of living, we have looked for some increasing of the schedules of salaries; but in vain. We have no report of any such increase recently.

Sometimes, when the physics teacher is struggling to repair some piece of broken apparatus, or is poring over the note book of some pupil who can neither cipher, spell nor write, a faint suspicion crosses his mind that all of this equipment, valuable as it is to the student, is a little hard on his own family, as the feeling is apt to creep in that his own salary is sacrificed for the equipment. Then it is he wends his weary way homeward, calls up his oldest son, and says: "Well, John, if you still yearn more for work than for study, go ahead; after all, it doesn't seem to pay to spend a decade in learning how to teach." And thus the schools lose another student and the country a teacher. It seems to be conceded that teachers are philanthropists, and they are willing to be philanthropists; but they sometimes feel as if they would like their charity to begin at home.

We find the tendency also is to devote more time to physics. Many schools report increased time, and only one a decrease. Milwaukee has reduced the time from seven periods per week to five. On the other hand Buffalo has increased this year from one-half year to one year. Baltimore and Cambridge now offer two years. The Chicago teachers hope soon to offer at least a year and a half. But perhaps the most encouraging report comes from St. Paul. There not only is the usual amount of physics offered, but also a course in electrical engineering and one in photography, both of which the teacher, Mr. Schmidt, reports as being very popular and valuable. They also offer a course in surveying, which in a way connects mathematics and physics, being offered as the last term in the four years' course in mathematics.

This combination of mathematics and physics brings us to the recent action of Mr. E. H. Moore of the University of Chicago. At the conference of the affiliated schools held at the university on November 8, he sought to bring about a closer relation between mathematics and physics, and is following that up vigorously, as we shall perhaps see this afternoon.

Every live teacher of either of the subjects, we think, will appreciate the need of this.

And in closing it will, perhaps, be interesting to speak of the discussion at the same conference at the university of Chicago in reference to changing the educational program of the public schools and colleges so as to give to the high school six years instead of four, two of which would be practically college years. If this should be brought about at any future time it would no doubt give to physics two years instead of one. And the value of our new laboratories which are being so generously provided, could then not be questioned.

Mr. E. C. Woodruff of the La Grange (Ill.) high school, chairman of the committee on a set of laboratory experiments, then read the following report:

The object of most reports heretofore presented on lists of laboratory experiments has been to suggest a minimum list of standard experiments that would cover the essentials of the subject and satisfy the average college-entrance requirements. The object of the list herewith offered is much more complex. It attempts:

1. To include the experiments mentioned in such "standard" lists.

2. To suggest a number of optional experiments, perhaps the maximum number for a general course, that will permit the teacher to extend his course to suit his particular desires or requirements and yet to keep within the bounds of the criteria to be mentioned below.

The criteria to be considered in making out such a list are as follows:

1. Experiments that should be performed by the teacher in class should not be used in the laboratory under the impression that the pupils will gain anything by performing them themselves.

2. Experiments in which the normal teacher cannot arouse the interest of the normal pupil should be omitted. By such are meant experiments that the pupil is liable to stigmatize as "trifling" either because his previous experience enables him to go through all the operations in imagination more quickly and even more efficiently than in actuality, or because the operations and results are so obvious and simple that the mere recital thereof is sufficient.

3. Experiments that do not fulfill at least two of the requirements mentioned below should be omitted.

The essential requirements under which an experiment becomes eligible for consideration are:

1. The experiment should have a stimulating effect on both pupil and teacher.

2. Some general law may be quantitatively illustrated.

3. The experiment may have a direct bearing on the solution of some numerical problem.

4. The experiment may give the pupil an insight into and an in-

tertest in some phenomenon of his environment outside of his school life.

5. There may be some training in method and technique.

It is thought that the list herein submitted:

1. Includes all the experiments that fulfill the above requirements and that are at the same time possible in the laboratory of a secondary school.

2. Possesses sufficient scope and flexibility to fit the needs of both the brightest and the most mediocre pupil.

3. Has the experiments listed in an order especially logical and suggestive.

The experiments are lettered according to difficulty, A, B, C. The A's are those each one of which may be performed by each pupil. Of the B's each pupil may perform about 50 per cent, elected according to their individual interests or needs. Of the C's the better pupils may be permitted to elect a limited number after having satisfied the requirements in the other groups.

Many of the references for some of the B and C experiments are a little unsatisfactory in that they do not treat the experiments in as full or precise a way as is desirable for optional extended work or even for work of what might be called "standard" grade. The number of experiments that fall under this head is about 20, besides those for which there are no references. As samples of such are numbers 9, 14, 20, 23, 66, 60, 63.

Many of the experiments listed are original with members of the committee and their friends and as yet are not accessible in print. But of these some are now appearing in various magazines. However, the mere enumerations of the title will no doubt be suggestive to the teacher who wishes to plan for better things. Stewart & Gee's "General Processes" and Perry's "Mechanics" will be of value in these cases. Any questions about the list will be very welcome at any time.

Number.	N. S. & T.	Ayres.	Chute.	Adams.	MECHANICS:	
		1	11		METRIC SYSTEM.	
1	1	2	16		Metric rule	A
2	6	9	22	22	Balance and burette	A
3	3	4	14	3	Micrometer caliper	A
4	2	5	13	2	Vernlered caliper	A
5					Spherometer	B
					STRENGTH OF MATERIALS.	
6	17	14	26		Tensile strength of wires, etc.	A
					ELASTICITY.	
7	15	16		4	Hooke's law and Jolly's balance	A
8	14	15			Hooke's law and Young's modulus by stretching.	A
				8		
9	13	17		9	Hooke's law and laws of flexure	B
10	16	18			Hooke's law and laws of torsion	B
					FORCES AND MACHINES.	
11	21	19	32	11	3 parallel forces in equilibrium	A
12	22	20	30	10	3 non-parallel forces in equilibrium	A
	23	21				
	24					
13	26	22	36	12	Levers.	A
14	28	23	37		Pulleys and forces at various angles	A
15					Simple crane	A
16					Guyed crane	B
17					Simple and differential windlass	A
18					Open and closed manometers	A
19				16	Inclined plane	A
					MOTION:	
					UNIFORMLY ACCELERATED MOTION:	
20	19		34		Galileo's method	B
21					Atwood's machine	B
22				13	Freely falling body [S. & G., No. LIII.]	BC
					SIMPLE HARMONIC MOTION:	
		27		14		
23	20	28	35	15	Simple pendulum	A
24			33		Conical pendulum for curvilinear motion	B
25					Torsional pendulum	C
26					Inclinable pendulum for g	B
27					Horizontal pendulum for period and force	C
28					Longitudinal vibrations in springs	C
29					Torsional vibrations in springs	C
30					Flat spring vibrating in its own plane	C
					FRICTION:	
31	30	26			Sliding friction	A
32		26			Friction on various roads	B
33					Friction in liquids [by means of siphon.]	C

Number.	N. S. & T.	Ayres.	Chute.	Adams.		
					FLUIDS: GASES:	
		30	44	21	BOYLE'S LAW:	
34	35				"Guthe & Miller" form	A
35					"Michigan method" C. & C. p. 138	A
					CHARLES' LAW:	
36	66	41	65	31	Coefficient with constant pressure	A
37		42			Coefficient with constant volume	B
38					Specific gravity of gases	C
39	32			20	Vernlered barometer	A
					LIQUIDS:	
					ARCHIMEDES' PRINCIPLE.	
	37					
40	39	31	46	23	For a body heavier than water	A
	38					
41	39	47			For a body lighter than water	A
42	40	32	48	24	Specific gravity of bodies heavier than water	A
43	42	33	49	25	Specific gravity of bodies lighter than water	A
	41		50			
	43					
44	47		55		Specific gravity of bodies by using the Jolly balance	A
					SPECIFIC GRAVITY OF LIQUIDS.	
45	46	34	53	26	Sinker method	A
46	44	35	52	27	Bottle method	A
47	50	37			Hydrometer method	A
48	49	36		28	Hare's method	A
49	48		54		By balanced columns of 2 liquids	A
50	51		51		Specific gravity of soluble substances	A
					SOUND:	
	114		104			
51	115	69	108	57	Wave length by resonance	A
52					Melde's experiment to demonstrate all the laws of strings. Tyndall, pp. 139-143	B
53	118	68		56	Tuning fork graphics	B
	119	71		53		
				54		
54	120	72	111	55	Sonometer work	B
55					Velocity of sound: In air: direct	C
					Velocity of sound: In air: reflected.	
					Velocity of sound: In R. R. track	C
56	109				Ripple trough work	C
57	121	70	105	58	Kundt's method for velocity in solids	C
58			107		Interference experiments	C
					LIGHT:	
					REFLECTION:	
		75	117	61		
59	126	76	119	62	Plane mirrors	A
		77	120			
		78	to	63		
60	127	79	125		Curved mirrors, cylindrical and spherical	A
					REFRACTION:	
61	128		126	70	Index from air to water	A
62	129		127		Index from air to glass	A
			128	64		
			129	to		
			132			
63	130	80	134	69	Converging lenses	A
		83		71		
64		84	118	72	Angles and index of a prism	B

Number.	N. S. & T.	Ayres.	Chute.	Adams.		
					APPLICATIONS:	
65	131	82	130		Model of telescope and compound microscope....	A
66		82			Magnifying power of a telescope	A
67					Exploration of a curved surface.....	C
68					Dividing engine measurements	B
69					Weighing with optical balance	B
70					Work with optical lever [S. & G. XVI.].....	C
			115	59		
71	125 57	74	116	60	Photometric work	B
					HEAT:	
72	58	38	58	29	Thermometric fixed points	A
73	59	43	66		Melting points of solids	A
74	64	39	63	30	Expansion coefficient of solids	A
75	67	46	73	33	Latent heat of fusion of ice	B
76	68	47 44	74	34	Latent heat of vaporization of water.....	B
77	69	45	70	32	Specific heat of solids	B
78	70		71		Specific heat of liquids by rate of cooling.....	C
79					Latent heat of fusion by rate of cooling.....	C
					MAGNETISM:	
	71 to	48		25 to		
80	80	49	75	28	General magnetic work	A
81					Magnetic exploration of a room, (for poles).....	A
82					Exploration of a magnetic field with a Jolly balance	B
83					Exploration of a magnetic field by vibrational methods	B
					ELECTRICITY:	
83	87	50	84	39	Simple voltaic cell	A
84	89	50	85	41	Action of a current on a magnetic needle.....	A
85	90			40	Helices and electro-magnets	A
86	88				Electrolysis of Cu S O, and of K I.....	A
87	91				Effect of resistance in a circuit	A
88	92				Effect of a magnet on a galvanometer	A
89	93		86	42	An electromotive series	A
90	95	65	93	46	Battery grouping	A
91	96	56 57 58	89		Resistance by substitution	A
				47		
					Measurement of Resistances.	
92	98	59	90	48	Slide bridge, singly, in series, and in parallel...	A
93	102	60			Effect of temperature on resistance	B
94					Resistance of Electrolytes	B
	104	51 52	94	43		
95	106	53	95	44	Galvanometer calibration	C
96					Instrument assembling, galvanometers, motors, etc.....	B
97					Manufacture of Resistances	C
98					Condenser methods for E. M. F.....	C
99				49	Potentiometer methods for everything	C
100					Testing dynamos, motors, lamps, relays, etc....BC	

The printed program contained a list of eleven topics to be discussed informally. Lack of time permitted of the discussion only of the following:

How much setting up of apparatus should the $\frac{\text{pupil}}{\text{teacher}}$ do?

Should laboratory directions be very explicit as to how the experiments are to be carried out, or should the pupil be left largely to himself as to the mode of performing an experiment?

Leader, director, co-worker, inspector, information bureau, policeman, spectator—which is the teacher's chief function during the laboratory period?

Why is it that students come to us with insufficient mathematical preparation for their physics?

Would it be possible to organize the subject matter of algebra, plane and solid geometry and physics into a thoroughly coherent four years' course?

The laboratory method of instruction: What are its essential elements? Is it applicable to mathematics?

The discussion was lively and interesting and that of the first three topics showed that there was considerable difference of opinion and variation of practice. The discussion of the topics concerning the correlation of mathematics and physics teaching showed that all participating in it were of the firm belief that this correlation should be much closer and thoroughgoing than is at present the case. Several prominent mathematical teachers who were present expressed themselves as heartily in sympathy with any movement which would tend to introduce more of the laboratory method into the teaching of mathematics. On special motion the executive committee was directed to arrange for a conference with the mathematics teachers of Chicago and its vicinity whereby more definite action might be taken. [This conference met December 15, at Chicago, and appointed a committee consisting of Messrs. P. B. Woodworth (Lewis Institute), E. H. Moore (University of Chicago), C. E Linebarger (Lake View high school), C. R. Mann (University of Chicago) and E. C. Woodruff (La Grange high school), to draw up a definite course in laboratory mathematics for secondary schools, the same to be presented at the spring meeting of the association.]

After the adjournment of the afternoon meeting the members participated in an excursion to the power house of the Metropolitan West Side Elevated Railway Co., and the Harrison street plant of the Edison Electric Co., assembling at 7 P. M. at Kinsley's restaurant for the banquet.

The following toasts were responded to: *Physics and Invention*, by Mr. J. E. Armstrong, principal of the Englewood (Chicago) high school; *The Relations of Physics and Medicine* (see page 443 of this number), by Dr. Winfield Scott Hall, professor of physiology, Northwestern University Medical School; *Physics and Machines*, by Mr. Rob-

ert Hall Wiles, mechanical expert; *Physics and Mathematics*, by Mr. E H. Moore, head professor of mathematics, University of Chicago; *Physics and Engineering*, by Mr. S. G. McMeen, chief engineer, switchboard department, Western Electric Company; *Physics and Visions*, by Mr. A. A. Upham, department of physical science, Whitewater (Wis.) normal school.

All day Saturday, November 29, was given up to an excursion to the Illinois Steel Company's works, the Chicago Ship Building Company's yards and the works of the American Smelting and Refining Company.

Reported by C. E. LINEBARGER.

Correspondence.

EDITOR SCHOOL SCIENCE:

Dear Sir—Personally, I should like to see something on laboratory work in physiography given in SCHOOL SCIENCE. I am interested in this line and would like to compare notes with others.

The following has proved enjoyable in our work in biology: Once a week we discuss the life of a great scientist. Pupils are notified the preceding week who is "up" for discussion and are asked to go to the reference library and read a short sketch of the man's life. Then we talk very informally of the period in which he lived, of his own life, books, work, etc., and try to see what he has done for the world.

Pupils who hand in a brief set of notes from their reading are given credit for this, as for any other work. It was originally planned to take up each scientist on his birthday and call the exercise "biological birthdays," but this order was found to be inconvenient.

Grand Rapids, Mich. GRACE F. ELLIS.

School Science

VOL. II] MARCH, 1903. [No. 9

PREPARATION AND TRAINING OF THE TEACHER OF CHEMISTRY.*

BY DR. LYMAN C. NEWELL.

State Normal School, Lowell, (Mass.)

A recent number of a popular educational journal contained the following significant statement: "One becomes weary of listening to the numerous descriptions of what the teacher ought to be, when teachers are and will continue to be just ordinary mortals." At a first glance this assertion seems true, but a more careful consideration leads us to conclude that it is a specious half truth. The programs of educational gatherings during in the last five years in this country and in England have had one marked characteristic, viz., an unusually large number of papers and addresses on the art of teaching. This is specially true of those meetings devoted to science. At the meeting of the American Association for the Advancement of Science held at Denver in August, 1901, seven papers on the teaching of chemistry were read before the Chemical Section, one of them being the annual address of the vice-president and chairman of that section. These papers covered all branches of pedagogic chemistry, and their presentation confirms the view that, however weary some may be of hearing what a teacher and teaching should be, all are not disposed to ignore the public presentation of this means of improvement.

*An address delivered at the Sixth Annual Conference of the New York State Science Teachers' Association held at Syracuse, N. Y., Dec. 27-28, 1901.

Progress in teaching comes largely from consultation, comparison and publication. Bad methods can never be eliminated by concealment, nor can good ones be spread by hiding them under a beaker or in a water bath. Methods need constant regeneration. Education, specially in science, is evolutionary. There are few long steps, few sudden leaps in our work. We must keep moving; the fountain must be constantly playing. Cessation is stagnation. I hope the time will never come when we can not talk, write, consult and argue about our work.

Teachers of chemistry need a broader, more uniform, and more accurate knowledge of the fundamental facts and principles of chemistry. The foundation is essential to the stability of any superstructure. If our knowledge of the fundamentals is uneven, or out of plumb, then our superstructure will be rickety and in danger of cracking or of falling over at some critical moment. Several reasons lead me to emphasize this factor in considering the preparation and training of the teacher of chemistry.

At the last meeting of the Johns Hopkins University Alumni Association of New England a classmate, who is connected with a large college, said, "The weakest part of our course in chemistry is the general inorganic for beginners." This is true, no doubt, of many other colleges. Several unfavorable conditions attend the instruction of beginners in chemistry in college. The laboratory sections are often too large to permit individual instruction, the text is usually presented to indifferent listeners in the form of entertaining lectures or of an intricate outline, and the course itself is often condensed to ridiculous brevity in order to conform to the unavoidable restrictions of the curriculum. It is true that these conditions are sometimes unavoidable and that the department of chemistry is only partly responsible for them. Nevertheless, the students suffer, and too many graduate from college inadequately prepared to teach elementary chemistry, because their instruction in that portion of the subject has been irregular. It is as true of chemistry as of most subjects, that we know best what we studied last. And many a recent graduate attempts to force his latest work on suffering and helpless beginners. President Remsen once said that when he left

the University of Tübingen he could teach the most advanced organic chemistry better than the elementary inorganic chemistry. In many colleges the student passes directly from general chemistry to qualitative analysis, then to quantitative analysis, and finally to organic chemistry or some other advanced work. Seldom does he have a chance to review his general chemistry from a broad standpoint. There is a tendency in some institutions to remedy these defects, and before many years students while in college will be able to lay those broad foundations which are so essential for effective teaching of elementary chemistry.

A second reason for emphasizing the necessity of a better knowledge of the fundamentals is that in the last five years such an enormous number of facts has been literally hurled at us that those houses which are built on the sand are in danger of being swept away. Physical chemistry, electro-chemistry, chemical inactivity at low temperatures, dissociation at high tempera-

itter inert at all temperatures, radiant energy, molecules of eight atoms, molecules of a single atom, and liquefied gases galore have been suddenly thrust on us. I am not a foe to these newer conceptions, nor am I indifferent to the magnificent results obtained by such men as Ramsay, Nernst, J. J. Thomson, van't Hoff and others. But important as these topics are and will become, they should not be allowed to usurp or obscure our conception of the foundations of chemistry. A teacher in a large high school was asked by the writer what use he made of the theory of electrolytic dissociation. He replied, "I did considerable with it last year, but this year I shall do very little because my pupils did not see so much in it as their teacher did." Doubtless a similar vision of the situation led one of the best known teachers of chemistry in this country to say in the preface of his latest book, "In the opinion of the author the time has not yet come for the abandonment of the study of the elements and their compounds in what some are pleased to call the old-fashioned way. Indeed it seems essential that such study must always form the basis of the higher or spiritual study of chemistry." In a few years, no doubt, many of the simpler aspects of physical chemistry will form a part of our elementary courses in chemistry and must therefore be assimilated by teachers, but since physical

chemistry is now only a part of the superstructure, it should not be mistaken for the whole edifice. Only the teacher who has a broad knowledge of fundamentals can appreciate the meaning of new details, for such a one alone can determine the value of component parts of the whole. Comfortable teaching is based on an accurate knowledge of the first principles, it rests on unshaken confidence in the primary truths. The teacher who lays the foundations wide and deep need never fear overthrow. On them he can build with assurance as high and attractive a superstructure as desired. A teacher runs no risk of being left behind in taking a year or more to strengthen the foundations. He can easily catch up with the facts, and as he moves onward these facts will find a logical and permanent location in his mind.

A convenient and efficient way to obtain a knowledge of the underlying facts and principles of chemistry is by a judicious and thoughtful study of one of the large manuals of chemistry, such as Remsen's, Mendelieff's, or Freer's, Newth's, Richter's, or Roscoe and Schorlemmer's. Working familiarity with any of these books is an enviable acquisition. They are reservoirs from which we may draw our supply at any time. Make a business of it. Take a year for the task, if necessary. Read with a notebook at hand, or better still mark the margin of the book itself. Determine to remember where and how the facts and principles are treated. Imbibe the spirit of the author, see the truth from his standpoint. Do not be satisfied till the task becomes a pleasure. Gradually the whole panorama will come into view, facts hitherto unknown will assume their proper relation to the whole subject, experiments which one may have thought were his own discoveries will be accredited to the rightful discoverer (possibly Boyle or Lavoisier), laws will reduce themselves to that beautiful simplicity which is an expression of an harmonious nature, theories instead of being mere guesses will inspire to deeper thought and perhaps to intelligent experiment, and out of the vast mass of facts, laws, hypotheses, and theories a foundation will unconsciously be laid on which can be built with confidence and skill a superstructure in which ideas new and old may be harmoniously, artistically, and truthfully incorporated.

The preparation and training of the teacher of chemistry

should not be confined solely to this science. Interest should be stimulated in allied sciences. No single science is an independent unit; all overlap. Chemistry has some connection with all the physical and life sciences. Together with physics and pure mathematics it forms the great triangular foundation of physical science. Hence a general knowledge of other sciences is not only helpful but to a certain degree necessary to the successful teaching of chemistry. Such a knowledge keeps one from becoming warped and prejudiced in his judgment of the methods, value, and significance of other subjects in the curriculum. Love and enthusiasm for chemistry should not mean contempt and hatred for physics or biology. In answer to the question, "Do you prefer to teach another science besides chemistry?" 19 out of 20 representative teachers in Massachusetts replied "Yes." Those who taught physics invariably regarded this additional work as helpful. The speaker has found physics and mineralogy exceedingly helpful in interpreting many phases of general inorganic chemistry. A science needs a margin, a sinking fund, a reservoir, just as a picture needs atmosphere or a poem needs inspiration. A knowledge of perspective alone will not make an artist, nor will a knowledge of prosody make a poet. And it is just as true that a knowledge of chemistry alone will not make a good teacher of that science. We need "the more" to apply "the little," something beyond the subject to teach subject-matter. Our point of view, our estimation of values, our humor, our judgment, our mental horizon, our general reading, and our hints for the pupil's reading, all these really depend on something outside of mere chemistry. Photography, astronomy, mineralogy, geology, and physical geography stimulate interest in certain aspects of chemistry. This margin, this finish, this better part is that indefinable something which places the inspiring teacher on the right hand and the dull pedagogue on the left.

Probably most teachers of chemistry have at one time or another studied other sciences. It is advisable to arouse this dormant interest and to acquire a generous sympathy, a working knowledge of these sciences. This may be done by reading the scientific journals, such as *Science, Scientific American, Popular Science Monthly, American Journal of Science, Journal of the*

Franklin Institute, and by all means the latest journal, SCHOOL SCIENCE. Avoid newspaper science. It is usually downright absurdity or barefaced error. A few hours' judicious reading during a month will suffice to keep pace with all that one need know of other sciences. Form the habit of reading these journals and stick to it. A German professor was once asked about the progress of a former student. He shook his head and replied, *"Ach, er liest nicht mehr"* (Alas, he reads no more). Let us take care that we are not similarly condemned.

A few years ago the New England Association of Chemistry Teachers sent out a list of questions, mainly to New England teachers, covering all phases of teaching. Among the questions was this one, "What is your aim as a teacher of chemistry?" An answer which typifies the aim of the best teacher was, "To teach pupils a love for truth and for the science, and to develop a scientific spirit." A most desirable requisite which teachers themselves need is a scientific spirit, or, perhaps better, a scientific attitude of mind. The distinguishing feature of science teaching is not merely the provision of an opportunity to observe, conclude and record. Its vital object is to create and foster a scientific attitude of mind. The highest attainable result will follow, if a scientific spirit is aroused.

That attitude of mind called scientific is hard to describe. One of the most scientific teachers of chemistry in the United States said, "It is asking a great many questions, but few foolish ones." Some of its attributes are a determination to know all the evidence before pronouncing a judgment, precision in thought and statement, a desire to deal with the thing itself, not trusting to secondary sources, unshaken confidence in the triumph of truth, fearless abiding by tested results, willingness to change our conclusions when new evidence is presented, disbelief in the traditional superstitions and nonsense of our ancestors.

Sometimes contrast makes a subject clearer, and possibly the term scientific may be made clearer by illustrating an unscientific state of mind. To deny the truth of what displeases us is unscientific. It is also unscientific not to admit our errors, specially our published errors. It is likewise unscientific to accept

elastic theories. Prout's hypothesis, the evolution of the elements from a single element, and theories which violate the laws of thermodynamics belong to this class. It is furthermore unscientific to jump at conclusions which we would like very much to draw, if we only had sufficient evidence. How many new elements are annually announced! How many new discoveries are daily heralded which will set the earth spinning from the east to the west as soon as the pseudo-discoverer has obtained a little more evidence! We need more chemists like Morley and no more physicists like Tesla, we need more astronomers like the late lamented Keeler and no more like—well, I must not be captious. I am sure the point is clear.

Probably no general rule can be prescribed for the attainment of a scientific attitude of mind. Yet it can be cultivated. One of the best ways to acquire and foster it is to do some original work. It matters not how extensive or how slight the work, provided it possess the element of originality. Nature by some inscrutable law has decreed that we can learn only of and through ourselves, no one else can learn for us. The soul itself must come to a consciousness of the truth before knowledge is a possession. Every bit of original work coins knowledge. An original demonstration of the hitherto unknown properties of a chemical compound is worth more to the experimenter than a vast mass of memorized facts. The construction of a new piece of apparatus or the improvement of a method demands continuous exactness of thought infinitely more helpful in acquiring a scientific attitude of mind than can be gained by the remodeling of the whole scheme of qualitative analysis. One reason, I fear, why some teachers shrink from the performance of a few simple experiments demanding exact weighing or measuring is their inability—or would I not better say unwillingness—to carry out the train of reasoning involved in such work. A few hours a week—part of our wasted time—spent in the performance of some original work will soon give that attitude toward teaching science which a judge has in the trial of cases. It will give a mental grasp which is comprehensive enough to perceive the exact value of evidence. It will bring one face to face with truth.

It is imposible, however, for all teachers of chemistry in secondary schools to do research work. Numerous duties consume all spare time, apparatus and materials are not readily obtainable, and books and chemical literature are not always available. On the other hand, it is possible for such teachers to do some work possessing the element of originality. The simplification of apparatus, the wider application of new methods, the qualitative examination of some mineral, rock, mineral water, or industrial by-product offer ample opportunity for original work. Again, if no such work can be done, the teacher should write. Exactness of statement is a mark of exactness of thought. And exactness of thought may be acquired by critical writing. Put your thoughts into accurate language. Tell us about some interesting natural phenomenon in your locality, an example of chemical erosion, a piece of apparatus which has helped you over a hard place, write a brief biography of some of the living chemists, tell us about anything which interests you. What interests you will surely interest someone else. A managing editor of *The Sun* (New York), when asked by a correspondent what to write up, replied, "Anything that interests you—nothing else." Stevenson always carried two books in his pocket, "one to read in and one to write in." Publish what you write, read it before some association or to a friend. Help overcome the false notion that a scientist can not write clearly and entertainingly. Help make it impossible or at least untruthful for an editor to announce in a prospectus, "We assure you that these articles on science will be both good writing and good science, a combination that is unfortunately too often lacking."

Till about a decade ago chemistry was taught in high schools almost exclusively by a textbook. The pupil studied the book, recited what he had time to memorize, and occasionally listened to lectures or talks by teachers who often did some experiments. This unscientific method of teaching the science of chemistry began to be abandoned about ten years ago. Some schools went to the other extreme in allowing the pupils to do all the experiments, while the teacher did the studying and reciting. Fortunately the evil effects of this second unscientific method of

teaching the science of chemistry were soon discovered, and it is gradually being replaced by a judicious combination of individual experimental work done by the pupil, study, explanation, and recitation of textbook by the pupil, and informal lecture instruction by the teacher. It would be profitable to discuss the bearing of these three elements on the preparation and training of the teacher of chemistry, but the discussion will be limited to one phase of one element, viz., the supervision of laboratory work.

It seldom happens that a method of teaching changes suddenly, but when the change is abrupt, the application of the new method is attended with more or less misfortune. The laboratory method of teaching chemistry came on us rather suddenly, and in many schools its use has not only been injudicious but unprofitable. We know very little about its psychology and still less about its ethics. Many teachers can not account for their failures, and hence they are not slow to condemn the laboratory method, whereas it is the fault of the teacher, not of the method. Though my views on this question have appeared in print, I can not refrain from repeating some of them, because I believe the failure to grasp certain psychologic principles accounts for much of the aimless work done by pupils and for some of the unrest, discomfort, and inefficiency shown by many teachers in all sections of the country.

Laboratory work is concrete labor. It employs the hands as well as the head. Concrete labor is difficult to shirk. In studying history, geometry, or language the mind easily wanders. But when the mind is following an experiment in the laboratory, it does not readily ramble. Something is constantly happening; the mind being carried quickly from concrete to concrete has little or no time to roam. Apparatus must be arranged, chemicals collected, the experiments started, watched, controlled, or stopped. If, however, the teacher or the principal does not favor laboratory work, if the program restricts the experimental work to a pitiable minimum, if the teacher persists in explaining in the classroom what the pupil can think out unaided in the laboratory from his own data, then it is folly to expect the laboratory work to yield mental results. There must

be enough carefully prepared and judiciously supervised laboratory work to prevent the normal tendency to shirk, as well as to teach the pupil the supreme value of mental self-reliance. Again the experimental work must be dignified enough to command the self-respect of a thoughtful pupil but not so difficult or repulsive as to frighten him, for in either case the tendency to shirk will be hard to overcome. Furthermore, the laboratory work must be followed up by searching questions, for if the pupil once gets the idea that he need not think after he has completed his experiment, then you have opened for him a broad avenue for shirking. Each pupil should be taught at the earliest possible moment that he or she may be asked any reasonable question on any experiment. If such a spirit prevails, pupils soon learn to get from this concrete labor that invaluable acquisition, so often needed in later life, viz., the power to complete a piece of work accurately, quietly, quickly.

Again laboratory work is suited to relieve mental fatigue. It is restful work, if rightfully performed, because it affords opportunities for harmonious activity. But, if the laboratory period is too long or too short, if confusion reigns, if there is no opportunity for pupils, especially girls, to sit down in the laboratory while writing notes, consulting reference books, or performing slow experiments, if the directions for performing the experiments are brief, long, or so vague that their interpretation demands an excessive amount of mental energy, then mental fatigue will be increased, not relieved. The laboratory work under such circumstances can not afford that mental rest which it is designed to provide. Mind and body will refuse to act normally.

Third, laboratory work is a grand medium for the production of the highest grade of reactive conduct. Reception is followed by reaction, impression by expression. Motor activities are the expression of thought. But, if the laboratory work is inadequately supervised, owing to large divisions, program irregularities, or pedagogic inefficiency, then the reactive conduct will be of a low, perhaps the lowest, grade. The pupil who is called on to be doing something constantly should be stimulated by an environment which will enable him to do the right thing in

the best way. Good expression can not come from bad or meager impression. Teachers of chemistry who let the laboratory run itself, who do not help a confused pupil to regain mental poise, who do not realize that beginners need constant advice and direction, are unprofitable servants of the science of chemistry. The teacher's place is beside the pupil, showing him how to form good habits of observation, teaching him the difference between accuracy and vagueness, preventing him from doing slipshod or slovenly work, stimulating him to cultivate mental self-reliance, not telling him facts which he can observe himself, but suggesting legitimate channels for the application of his total power. I recall with pleasure my work under President Remsen, because he never discouraged me when I needed help and he always left me to myself when he saw that the best avenue to escape was through my own mental efforts.

Again, we must not be satisfied because our pupils are curious. Curiosity is a good sign, but at best it is only a means to an end. It should be encouraged at first, but, once active, it should be rationalized. Pupils must be led from curiosity to interest, from mere indiscriminate desire to know disconnected facts to an intelligent craving for systematic knowledge. The transition from curiosity to interest is a critical time for both teacher and pupil. Too often a thoughtless word, an unintentional oversight, or a palpable lack of interest on the teacher's part may upset the delicate poise of the pupil's mind and turn to permanent indifference or reckless curiosity what might have become lifelong interest. Special care should be taken by the teacher to gather up the disconnected observations made by pupils and place them before the learner in such a light that the threads of curiosity will become the fabric of interest. Once interested, the pupil should be led on into the realm of voluntary attention. It is this factor that we all need to develop, for it is of incalculable value in the acquisition of knowledge; it is essential to complete psychic life.

Pupils seldom see the importance of voluntary attention. They are contented to "do experiments" and stop there. They need to be taught the fundamental value of learning to complete with success an experiment requiring patience, skill and confi-

dence. The necessity of teaching voluntary attention is one reason why I believe so firmly that simple quantitative experiments should form a definite part of an elementary course in chemistry. Such work cultivates voluntary attention. As I have watched my classes for several years perform simple experiments involving accurate weighing or measuring, I have been forced to conclude that this work is the most effective way of teaching voluntary attention. It requires an effort of the will for spirited pupils to sit quietly before a balance till the pans stop swinging, to wait for a solution to run down the inside of a burette before the volume is read, to let a thermometer remain in a liquid long enough to assume the temperature of the liquid. But this very effort of the will is needed day after day when the pupil leaves school. It must be acquired, if one is to be a successful worker in any field.

Whatever or wherever our occupation, we shall always need the power to think continuously, work skilfully, and judge accurately. We do not need chemists half so much as we need men who will voluntarily attend to their work. The problems which are coming on us as a nation need for their solution men who have been trained to do things accurately, with dispatch, with a regard for all the evidence, with a profound love for truth, for that truth which is so forcefully exhibited by the laws of chemistry, for that outer truth which arouses in one a consciousness of inward truth.

Closely related to curiosity, interest, and attention is the principle of inhibition. It was thought about half a century ago that certain nerves checked the action of certain muscles. This is doubtless true, but it is a narrow interpretation of a more general function of the nervous system. This conception of arrest has been extended to cover our mental life, irrespective of nerve stimulus as such, and is called inhibition. It is not necessary that an inhibiting idea be specially strong to arrest another idea, for here as elsewhere the mental machinery is delicately adjusted. A strong motor idea may be easily and completely inhibited by a simple and apparently foreign idea. Faint impressions on the confines of consciousness may throw a strong idea completely off the track. Some trivial observa-

tion may upset a thought which is seeking expression, and either arrest it completely or so modify it that the final judgment is delayed or even completely abandoned. Pupils should not be allowed to yield to unwarranted inhibitions. Provision should be made in all laboratory work for allowing the pupil's mind to travel without needless inhibitions from the object of the experiment through the manipulation to the conclusion. The work should be so supervised that pupils will see the whole field of consciousness and not yield to reckless impulse or foolish inhibition. Many books now in use actually prevent the mind from acting calmly, continuously, and logically. Experiments to be mentally profitable should be so expressed and arranged that the average pupil can not fail to grasp the title, the exact method of procedure, the essential observations to be made, and the probable conclusion which the observations will permit. The title of each experiment should be known so that the pupil may have an initial idea, a mental start, a guiding star. Unless he begins correctly, he may not, probably will not, end correctly. A knowledge of the exact method of procedure is essential, otherwise he will not know how, when or where to begin his work, nor can he carry it on intelligently, confidently, profitably. A great deal of time is wasted in a laboratory because pupils do not know how to work, and in many cases they are not to blame for this aimless, fruitless labor, because they were not at some time told or shown how to work. They yield to some foolish inhibition or reckless impulse, simply because they see no other path. Again, the desired observations should be indicated in some way. Pupils are learning how to observe; one object of experimental work is to teach observation. Surely we ought not to assume what we are trying to teach. Beginners do not know the difference between the trivial and the important, the scientific and the unscientific. They must be pointed toward the path having the fewest inhibitions, even though such direction reveals some truth which they might possibly discover if sufficient time were taken. Finally, each experiment should lead to some definite result. Otherwise the student is left suspended, is actually robbed of the inestimable privilege of drawing a conclusion. Experience shows, however, that this conclusion must

be indicated. It need not be deliberately told, but it can be suggested by appropriate questions. Such questions eliminate inhibitions, they conduct the mind along a logical path, they extend a helping hand to a halting thought, they train the mind to pass from cause to effect.

If you ask how the teacher may attain the power to apply these principles, the answer is simple. Study your pupils and yourself, but yourself the more. The problem has only two unknown quantities—yourself and your pupils. Success depends on the teacher's knowledge of his own psychologic and spiritual life as well as on the discovery of mental crises in his pupils. He must create an atmosphere which fosters calm, deliberate, confident, tranquil mental action. He himself must have passed through the gates of curiosity and interest into the temple of voluntary attention before he can lead others to the same spot. He must acquire that spiritual insight which perceives the truth in himself, he must be constantly conscious of that better self, for it is this unseen self which teaches.

HIGH SCHOOL BOTANY.

BY V. A. SUYDAM.

Supervising Principal, Public Schools, Ripon, Wis.

(*Concluded from page 438.*)

In all subjects we aim first at a mastery of the broad general facts, in order that we may get a perspective of the subject as a whole, and then, if it is pursued further, we study into the details. After the subject has been mastered in its broad general outlines a study of minute details can be taken up with profit, and not before. This study of details is the work of the specialist, is the work that the college aims to do, but which can be pursued with profit only after the student has mastered the broad general facts in schools below the college. Says L. H. Bailey, "The youth is by nature a generalist. He should not be forced to be a specialist." If we

attempt to do exact and technical work in the high school we are trying to reverse the order of the child's development, which must of necessity result in arrested development.

If there had been a well regulated course in nature study in the grades leading up to botany in the high school, then there might be some excuse for such a treatment of the subject, but in most schools, at the present time, no such course is given although it is offered in most cases. The only way to make botany in the high school a study worthy a place on the program is to make it a continuation of nature study in the grades, and not a scientific study of college botany which can have no interest or benefit to the pupil, because he has nothing upon which to build such a study. Even though we have a well regulated course in nature study in the grades, some of the botany that is being taught is too difficult for pupils of high school age. It is a misfit.

In my opinion, the child should be brought in contact with the plants about him. He should make a study of them, not a scientific study however, year after year from the first grade to the ninth, when he will be prepared to take up high school botany. This acquaintance ought not to be a hit and miss acquaintance, nor an attempt to become acquainted with all plants about him, but more particularly with those which have some human interest because they have in some way or another contributed to man's enjoyment or benefit, or because if harmful a knowledge of them becomes beneficial. Botany should be replete with human interests. It should be paved with common associations.

He should be taught to become acquainted with plants as living things, having a life cycle, and which may be benefited or harmed according to treatment. He should be taught to have a wholesome respect and even reverence for plants, such that may react upon his ethical and spiritual nature and thus become a potent factor in character building, before he begins the scientific study in a laboratory which treats plants more or less as inanimate objects. If this exact study is begun before the child has become acquainted with plants in their homes, and before he has become conscious of "an unseen power, of life in life and life behind life, of God, and of coöperation with the unseen life," it is quite apt to play no part in developing his ethical and spiritual nature, or, what

is more, he may even lose what feeling he may perchance have cultivated for nature. If the study of botany serves no other purpose than that of leading the pupil to higher ideals it will have a just excuse for a place in every course of study, but if the present method of study militates against this, as I believe it does in most cases, then it would be far better if the subject were left out entirely, and the child's only knowledge of botany remain that of chance acquaintance with plants which he may look upon as friends rather than the dry, lifeless and uninteresting things which he was forced to study in school, and which he remembers only with a pang. The little knowledge and discipline that is obtained under existing conditions is not worth the sacrifice.

The high school course in botany should be a continuation of nature study in the grades, whatever that may be. If there has been no nature study in the grades, then the child should begin at the beginning, using only the knowledge of plants he has perchance acquired as a foundation. Wherever or whenever he begins this study his acquaintance must grow ever wider and deeper, and with the life element always a prominent factor. Never, however, at any stage, should he go deeper into the study than at that particular time his stage of development will permit.

No doubt the present method of teaching botany trains the observation to some extent, disciplines the mind, and imparts some knowledge, the greater part of which is valueless to the average high school graduate. Botany should do more than this if it is to claim a place on the program to-day when there is so much to teach that is worth while. It should have an ethical value, and should impart useful knowledge about plants which have a human interest.

I believe that the kind or quality of botanical knowledge that is being taught is wrong for the high school. The knowledge should be useful knowledge. The course should offer something which would make the pupil feel that it is worth while to know, something that is necessary to fit him for life, rather than something that is to fit him for college. That which best fits the pupil for life ought to best fit him for college, otherwise the college had better get closer in touch with the human element in education. "Life is real, life is earnest," and it ought not to be marred by dull, lifeless, and meaningless exercises in botany which can have

no other result than that of dulling the senses and feelings, and occupying time which could be better spent.

To give useful knowledge of plants may not always follow the "scientific" treatment of the subject, yet, in my opinion, useful knowledge ought not to be sacrificed in order to follow out some "scientific" treatment. There is so much of botany that has a direct human value, that it seems an utter waste of time to study out problems for the sake of the problems, or to study out the parts of plants and their minute structure which are wholly unrelated to man's needs. If a course in botany could be worked out along the lines I have indicated I think much of the criticism we now hear about botany would be removed.

Botany when taken up in this way will furnish the maximum development of mental power and character. The mind will always be coping with problems within its range, and the feelings will be stimulated rather than blunted. There are numberless problems to be solved which are at the same time useful and disciplinary. The powers of observation, too, will be developed as they never can when the pupil is confined to a study of details in a magnificent and over-equipped laboratory. The subject will be made a live subject, dealing with things of life. It will be made real and fascinating. Pupils will take to it because it is within their mental range, and because it is a study of the most important gift of Nature to man—the plant. A subject which deals with objects of such great importance to man ought not to be barren of results if taken up in the right way. That it has been so unprofitable a study, I take it, is largely because we have been dealing with the wrong phase of the subject. The quality of knowledge has been wrong.

It would seem to me, that it goes without saying that botany work in the high school which gives a broad general view of the subject, which acquaints the pupils with plants as living, growing and useful, ought to be the best preparation for the pupil who goes directly from the high school into life's work, and also the best preparation for the special work which the college aims to do. The high school must fit the pupil for life first, and if this preparation at the same time fits him for college, so much the better. It seems that botany, when rightly treated, ought to do both at the same time.

THE TRAINING AND WORK OF A GEOLOGIST.

BY C. R. VAN HISE.

Professor of Geology, University of Wisconsin.

Geology is a dynamic science, subject to the laws of energy. Geology treats of a world alive, instead of, as commonly supposed, a world finished and dead. The atmosphere, or sphere of air, is ever unquiet; the hydrosphere, or sphere of water, is less active, but still very mobile; the lithosphere, or sphere of rock, has everywhere continuous although slow motions. The motions of the atmosphere, the hydrosphere, and the lithosphere alike include body motions by which the positions of large masses of material are changed, and interior motions, through which the mineral particles are constantly rearranged with reference one to another, and indeed are constantly remade.

No science is independent of other sciences, but geology is peculiar in that it is based upon so many other sciences. Astronomy is built upon mathematics and physics. Chemistry and physics to a considerable degree are built upon each other. Physics also requires mathematics. Biology demands a limited knowledge of physics and chemistry. However, it cannot be said that a knowledge of the basal principles of more than one, or at the most two, other sciences is an absolute prerequisite for a successful pursuit of astronomy, chemistry, physics or biology. This is not true of geology. In order to go far in general geology one must have a fair knowledge of physics, chemistry, mineralogy and biology. These may be called the basal sciences of geology. In certain lines of geology the additional sciences, mathematics, astronomy and metallurgy, are very desirable.

Geology treats of the world. In order to have more than a superficial knowledge of geology, it is necessary to know about

Vice-presidential address, Section E, Geology and Geography, American Association for the Advancement of Science, Pittsburg meeting, 1902. The extracts of the address here given seem as applicable to the student in the secondary school and as helpful to his teacher as to the more advanced students to whom it was addressed.

the elements which compose the world; how force acts upon these elements; what aggregates are formed by the elements and forces, and how life has modified the construction of the world. Chemistry teaches of matter; how it is made up, both in life and in death. Without an understanding of its principles we cannot have an insight into the constitution of the earth or of any part of it. Physics teaches of the manner in which the many forms of that strange something we call force acts upon matter. Without a knowledge of its principles we can never understand the transformation through which the world has gone. The elements which compose the earth under the laws of physics and chemistry aggregate into those almost lifelike bodies which we call minerals. The minerals are commingled in various ways in the rocks. Without a knowledge of mineralogy no one can have even a superficial understanding of the constitution of rock masses. Biology teaches of the substances alive which clothe the outer part of the earth. Life is one of the most fundamental of the factors controlling the geological transformations in the surficial belt of weathering; it has acted as the greatest precipitating agent in the sea. Life has had, therefore, a profound and far-reaching effect in determining the nature of the sedimentary formations.

The sciences of chemistry, physics and biology have been built up by using minute parts of the materials of the earth. If geology, or a science of the earth, is to be constructed, it must apply to the earth as a whole the principles which have so enlightened us as to the nature and relations of the fractions of the earth, which we observe and handle in our laboratories of physics and chemistry and biology.

It thus appears that geology is a composite science; and it might in a certain sense be called an applied science. Indeed I have often defined geology as the application of the principles of astronomy and physics and chemistry and mineralogy and biology to the earth.

Certainly the earth is the single enormous complex aggregate of matter directly within the reach of man. This highly composite earth is the joint result of the work of astronomical,

physical, chemical and biological forces; working on an incomparably vaster scale than can ever be imitated in our laboratories. A study of these mighty results has already advanced at many points astronomy, physics, chemistry and biology, and future studies made with direct reference to the causes which have produced the earth are sure to lead to even greater advances in these studies.

If geology is to become a genetic science, or, more simply, is to become a science under the laws of energy, geology in large measure must become a quantitative science.

If I have correctly stated the relations of geology to the other sciences, it follows as a corollary that those only can greatly advance the principles of geology who have a working knowledge of two or more of the sciences upon which it is based.

By a working knowledge of a science I mean such a knowledge of its principles as makes them living truths. One must not only be able to comprehend the principles, but he must see them in relation to one another; must be able to apply them. It is not sufficient for a carpenter to be able to explain how the hammer and saw and plane and chisel work; he must be able to use them. He must be able to hit the nail on the head; to cut straight; to plane smooth; to chisel true; and do all upon the same piece of timber so as to adapt it to a definite purpose in a building. Just so the geologist must be able to apply as tools the various principles of physics and chemistry and biology and mineralogy to the piece of geology upon which he is engaged; and thus shape his piece to its place in the great structure of geological science. This is what is meant by a working knowledge of the sciences basal to geology.

It is not supposed that any one man has a comprehensive knowledge of all the basal sciences, or even a working knowledge of their principles; but such knowledge he must have of two or more of them if he hopes to advance the principles of geology. He will be able to handle those branches of his subject with which he deals in proportion as he has a working knowledge of the basal sciences upon which his special branch is based, and will probably correlate this branch with the other branches

of the great subject of geology in proportion as his working knowledge of the basal sciences is extensive.

For instance, to advance geological paleontology one must have a working knowledge of the principles of biology and of stratigraphy. To advance any of the lines of physical geology one must have a working knowledge of the principles of physics, and especially of elementary mechanics. To advance physiography one must have a working knowledge of physics and chemistry. To advance knowledge of the early history of the earth, one must have not only a working knowledge of physics and chemistry, but of astronomy. To advance petrology one must have a working knowledge of physics, chemistry and mineralogy. To advance the theory of ore deposition or metamorphism, one must know not only the principles of physical geology, with all that implies, but he must have a working knowledge of chemistry, physics, mineralogy and petrology. It is unnecessary to add that a geologist must be able to read some of the modern languages, and be able to express himself clearly and logically in one language.

Geology starts as an easy observational study, and gradually becomes more and more complex until it taxes the master mind to the utmost.

But too often men who have entered upon geological work have received no adequate training in chemistry, in physics, in biology; and therefore at the outset wholly lack the tools to successfully interpret the phenomena which they observe. But such inadequately trained men feel that a satisfactory explanation of any phenomenon must involve a statement of the underlying chemical or physical or biological principles. In such cases it is safe to say that the explanations given are extremely partial, including only a modicum of truth, and more often than not are absolutely fallacious. Indeed, no other result can be expected from one who lacks a working knowledge of the principles of physics, chemistry and biology. Occasionally there is a clear-sighted, capable man, lacking in adequate training, who does important geological work simply because he knows his limitations, and there stops. But this is very exceptional indeed;

and the physical explanations offered by many for various geological phenomena are no less than grotesque.

It has been made plain that a working knowledge of the sciences basal to geology is necessary in order to advance its principles. But I go even further, and hold that such basal knowledge is absolutely necessary in order to do even the best *descriptive* work. Good descriptive work is discriminative. Good descriptive work picks out certain of the facts as of great value; others of subordinate value; and others of no value for the purposes under consideration. How then can this discrimination be made? How can the facts be selected which are of service? Only by an insight into the causes which may have produced the phenomena. Without this insight to some extent at least a description is absolutely valueless. So far as the geologist has such insight, his description is valuable.

If my statement thus far be true, the outline of the training of a man hoping to become a professional geologist is clear. Such a man should be sent to thorough and long courses in each of the subjects of astronomy, physics, chemistry, mineralogy and biology. This means that a large part of the training of a geologist is the study of the sciences upon which geology is founded. If a man who hopes to be a geologist is wholly lacking in a knowledge of any of the basal sciences, this defect he can probably never make good. Even if he so desires, the time cannot be found. Moreover, chemistry, physics, mineralogy and biology are laboratory sciences and can be satisfactorily handled only in the laboratory. If the fundamental work in the basal subjects has been done in the college or university, one may keep abreast of their progress during later years; but in order to do this, the basal principles must have become living truths to him while a student.

In recent years it has been a mooted question in colleges and universities as to when specialization should begin, rather implying that when specialization begins broadening studies should cease. And, indeed, it is upon this hypothesis that most of the discussion upon this subject has been carried on. Some have held that specialization should not begin until late in the college course, or even rather late in a post-graduate course.

Others have held that one should early direct his studies to special subjects which he expects to pursue, and give comparatively little time to other subjects. The argument for this latter course is that competition is now keen; and if a man keeps in the race he must begin to specialize early. It appears to me that both of these answers are inadequate. My answer to the question is that specialization should begin early, but that broadening studies should not be discontinued. This rule should obtain not only through the undergraduate course, but in the postgraduate work and during professional life. The specialized work will be better done because of the broad grasp given by the other subjects. The broadening studies will be better interpreted because of the deep insight and knowledge of a certain narrow field. Thus each will help the other. No man may hope for the highest success who does not continue special studies and broadening studies to the end of his career.

But is it held that a geologist lacking an adequate working knowledge of basal studies cannot perform useful service? No, the domain of geology is so great, the portion of earth not geologically mapped and the structure worked out is so vast, the ore and other valuable deposits which have received no study are so numerous, that there is an immense field for the application of well-established principles. In geology, as in engineering and other applied sciences, there is an opportunity for many honest, faithful men to perform useful service to the world even if their early training and capacity are not all that could be desired. But even the application of old principles to new areas will be well done in proportion as the geologist has training in the basal sciences; and to the man who combines with such training talent must necessarily be left the advancement of the philosophy of geology. The philosophy of geology, the inner meaning of phenomena, was the paramount consideration to Hutton and Lyell and Darwin. To them facts were useful mainly that they might see common factors, the great principles which underlie them, or, in other words, generalization. To correctly generalize in geology involves the capacity to hold a vast number of facts in the mind at the same time; to see them in their length and breadth and thickness; to see them at the same time

as large masses and as composed of parts, even to the constituent mineral particles and the elements; to see the principles of physics and chemistry and mineralogy and biology interlacing through them. Only by holding a multitude of facts and principles in one's mind at the same time can they be reduced to order under general laws.

Failure thus to hold in one's mind a large number of facts and principles leads to lack of consistency. Often in a single book or a single chapter, on the same page, or even in the same paragraph or sentence, are contained ideas which are exclusive of one another. They are not seen by the writer to be exclusive of one another because he is so lacking in a command of the principles of the basal sciences that he is not aware of the antagonism. But the man who sees the phenomena and principles of geology in all their complex relations, and tries to express the parts of them he is considering in proportion to one another, and to place his fragment of the science of geology in proper relations to other departments of geology and other natural sciences, has a task before him requiring great mental effort. He must see and understand in three dimensions. At every point he must see the lines of cause and effect radiate and converge upon the phenomena he is considering from many other phenomena and principles. Of course all fail to do this completely in reference to any complex problem. But in so far as success would be attained, the effort must be made. In proportion as one can hold many facts and principles and see their interrelations, he will be able to advance the philosophy of geology. This is the work which burns the brain.

And his results he must express in language, the chief means of communicating ideas and relations. Yet language is linear. By figures, models, maps and illustrations, wisely used, one may to an important degree supply the defects of linear language. Yet language and illustration, even where used to the best advantage, but poorly convey one's ideas. Most conscientious writers require as much or more time to put a complex subject into words and illustrations ready for publication as they do in working out the results.

But upon the other side, and in favor of expression in lan-

guage, it should be remembered that there is action and reaction between one's ideas and the attempt to express them in words and illustrations. The necessity for expression in language is often a wonderful clarifier of ideas. The ideas are improved by the attempt at expression, and the expression is continually improved as the ideas are enlarged.

As I have already intimated, I hold that for the best liberal education one must pursue broadening studies from the first to the last, and also that one must early begin to specialize. If this be true, geology may be said to be a very desirable part of a liberal education; for it is built upon the whole realm of pure science; *i. e.,* the knowledge, which applies not only to the earth and all it holds, including man, but to the universe as well. Because of the breadth of training combined with specialization required of a geologist, it might be shown that geology is one of the most useful studies in giving a person a sense of proportion, ideas as to relative values, of perspective, qualities of the first order in this world. It might be held that the intellectual training of the geologist is of a kind which helps him in dealing with men and things; and, therefore, for handling the world's work. But time does not suffice to develop this part of the subject.

I shall now suppose that a geologist is adequately trained, that he has some power in generalization, and consider what should be his method of work. It is assumed that the young geologist spends a part of each year in the field. This field work should include areal mapping with structural and genetic interpretations. The wider a young geologist has traveled, the more numerous the excursions in which he has taken part, the better will be his equipment. But no general work such as this can supply the place of systematic mapping. And the more exact the mapping is, the better the training. Very frequently the educational value of the mapping in detail of a small area is underestimated. Indeed, I hold that nothing else can take its place. Moreover, the only sure way to test a geologist is to require him to delineate upon a map and in structural sections the detail phenomena of the field. For my part I have more confidence in the

future of a young geologist who has mapped in detail twenty-five square miles, and has got out of the area much that is in it, than that of another who has done no detail work but has run over and written about thousands of square miles. Rarely can the general conclusions of a man who has not done systematic mapping be relied upon. In America there have been conspicuous cases of men calling themselves geologists who have never carefully mapped a square mile. Yet some of these by the undiscriminating have been regarded as leading geologists. And in one or two cases these men have gained a wide hearing. But the systems which they built up had little or no relation to the world; and they disappeared with the death of their authors. But a geologist must not only do systematic field work at the outset; he must continue to do such work through the years to a ripened age. Not infrequently a geologist, who in early life has done systematic field work, drops this work and continues writing geological philosophy; but this is a precarious course, which sooner or later makes of him what one of our members calls a "closet geologist." It is only by never-ending action and reaction between the complex phenomena of geology in the field and reflection as to the meaning of the phenomena that sure results can be obtained.

While one should spend a part of each year in the field, I suspect that many more discoveries of geological principles are made in the office or in the laboratory than in the field. The cow collects the grass in the meadow, and afterwards lies down to chew the cud and digest the food. So the geologist in the field, in the midst of innumerable facts, collects all he can. His notes are a record of his daily collections; and if a successful geologist, of his daily imperfect inferences and deductions. But during the eight or nine months of office and laboratory work he has full opportunity for reflection. He is then likely to see more of the common factors of the facts collected; is more likely to see deeper into the underlying principles which explain them.

While the work of each geologist should be based upon thorough field and office work, and thus have an inductive basis, one should not there stop, but should by deduction ever be looking

forward. No one ever held more firmly to fact as a basis for induction than Darwin; but also, no man has more successfully projected by deduction beyond his facts than Darwin. This in biology was a task of extraordinary difficulty. In geology one who has a firm grasp of the principles of physics and chemistry may be more daring. Their principles, if not more definite than the laws of biology, are at least better known and more simple. Therefore, one, after having observed the facts in a district and grasped the principles which explain them, may deduce what are likely to be the facts in the field and their relations in advance of observation. Or more concretely, after one gets the correct idea as to the meaning of the phenomena for a certain district, he often can tell in advance of observation what he will see; or can find what I call "geology made to order."

There is no better or more severe test of a theory than one's capacity to find geology made to order. If observation of the area where the facts are expected to be found in a certain way shows that nature does not obey the order, this is certain evidence that one or more factors in the problem have been omitted and that the theory is inadequate. In so far as the theory is adequate, the geology will be found as anticipated. The reason for this is the very great complexity and delicate adjustment of the phenomena of nature. To illustrate, if the many parts of some complex machine, such as a Hoe press, or a chronometer, were scattered far and wide, and then one should gather some of these parts, and try to fit them, he might find that a certain set fit perfectly. If this were so, he would know to a certainty that these parts are in the correct positions and relations, even if he did not know the relations of these parts to other parts or the purpose of the whole; for so complex and exact is the adjustment that there is but one way to put the parts together. Another set of parts might be found and these made to fit. But doubtless certain parts would not be found. These would be missing links necessary to make a perfect machine. In this situation, if the man had a genius for mechanical construction, and an insight into principles, he might be

able to understand the purpose of the whole, and finally to supply the parts which render the whole a useful machine. This he would be able to do just in proportion as he had mechanical insight.

So the geologist fits together his numerous diverse facts. If he finds a solution of his problem which gives accordance to all the numerous facts observed, he may be sure he is on the right track, even if he is incapable of seeing the full truth, for so delicate is the adjustment of facts that where they are numerous there is usually only one way to put them together. Just in proportion as the man has a working knowledge of the principles of physics and chemistry and biology, and the other cognate sciences will he be able to eliminate erroneous explanations, combine the facts into groups under true theories, and correctly infer how the different groups are to be adjusted, how the various facts which seem at first to have no definite relations are related.

Men with defective basal training and poor intellectual power will always fail when they try to put complex facts together under principles, and especially when they attempt to project by deduction beyond observed facts. But men who have a firm grasp of the principles of the sciences basal to geology, the capacity to correlate these principles and apply them to the facts of geology, will go beyond their observations and by deduction will reach conclusions with perfect confidence which are far in advance of observation. Indeed in this way only can the best geological work be done. After one has projected his deductions in advance of observations, he returns to the field with these new ideas, and then carries his observations farther than he was able to do before. The geologist whose ideas are not continually outrunning his observations will never go far in the science. He whose mind is behind his observations instead of in advance of them, will ever be mediocre. The minds of the leaders of geology are on the mountain heights before their feet have more than touched the foothills.

The conclusions deduced by a scientific genius may go so far in advance of observations that he who announces the conclusions may not be able to make observations which confirm

the theories during his lifetime. In such cases subsequent observations made through many years by others will find the phenomena confirming the principles. The truths announced by men of insight are often not accepted by slower men until this later observational work is done. Many cases could be cited illustrating these statements. Darwin, in 1860, knew that life had existed that would fill in the great gaps in the very imperfect paleontological record. Since 1860 all the greater gaps have been filled by discovered fossils. Mendeleeff, when he saw the law of the periodic arrangement of the elements, *knew* that elements exist which would fill the gaps; but it took many years of work by many men to find a part of them; and during the past few years a half dozen or more of the vacant places have been occupied. Each geologist, each scientist, now as in the past, is just as right as he should be. The scientific seers will ever go far in advance and guide others, even as did the spiritual seers of old.

The scope of these observations doubtless extends beyond geology. Much of what has been said is true of knowledge as a whole, not restricted to one subject. But I shall have accomplished my purpose if what I have said be true of geology; for if my conclusions be well founded, they furnish the basis upon which courses leading to degrees in professional geology should be laid out, and to methods of good geological work in the field and in the office.

THE EXAMINATION AND THE EXAMINEE IN ELEMENTARY SCIENCE.

BY JOHN WADDELL,

School of Mining, Kingston, Ontario.

The average examinee considers examinations as an ordeal which he must pass in order to obtain a certain certificate. He looks upon the examiner as a man whom he must try to convince of his knowledge of the subject, and if he can do this without excessive study, so much the better. No doubt, the examiner has largely himself to blame if the examinee can pass the examination

without a reasonable amount of study. The examination should not be of the kind that can be crammed for, but should require thoughtful application on the part of the student. It must not be of such a character that a candidate having accumulated a number of undigested facts without any knowledge of their relationships may be able to present a good appearance. If definitions are asked for, care should be taken to ascertain that the definitions mean something to the examinee as well as to the examiner. The words may be exact, the idea expressed may be perfectly correct, and yet the candidate may have no more conception of what is meant than if he had committed to memory a list of words taken from an unknown language. For instance, the statement of Avogadro's law, that equal volumes of different gases under the same conditions of temperature and pressure contain equal numbers of molecules, may be given correctly, and yet the candidate might be entirely at sea if asked what volume of hydrogen would contain five million million of molecules, provided that under the same conditions of temperature and pressure one litre of nitrogen contains a million million of molecules.

Not that I consider the memorizing of definitions useless. The strengthening of the memory has some value, but I think that storing the mind with gems of literature is preferable to accumulating a stock of definitions. Definitions, accurately and exactly learned, may doubtless be of use in later life when their meaning is understood, and in this respect the learning of a definition is better than the learning of a series of words in a dictionary or of a page in a table of logarithms. I refer to the learning of definitions without understanding their meaning. The learning of a definition, when the value of each clause and word is appreciated, is quite a different matter and is, in the highest degree, education.

The pupil beginning the study of science should realize from the very first the necessity of accuracy and exactness. He should learn that his knowledge, while necessarily limited, should be definite and distinct. A hazy idea of principles and facts is most unsatisfactory. The term *science* denotes *knowledge*, and knowledge should be exact and not of a general and indistinct kind. General knowledge has been wittily described as definite and dense

ignorance, and it must be admitted that many examination papers exhibit on the part of the examinees a great deal of general knowledge.

Accuracy of observation is one of the essentials of any scientific training, and any training is to that extent scientific in which accuracy of observation is insisted upon. If leaves are being examined, their shape should be accurately observed, the character of their margin, the texture, the surface, and other peculiarities, so that the pupil will realize that he *knows* something about the leaves he has studied. If flowers are examined, their peculiarities should be noted, and whatever object is looked at, the observation should be accurate so far as it goes. An examination paper can test such accuracy of observation. Taking an illustration from elementary chemistry instead of botany, such a question as the following may be asked, "What did you see when a piece of sodium was placed upon water?" The answer might involve the fact that sodium takes a globular form and moves about on the surface of the water; it might be that a yellow flame was seen; but that hydrogen was produced by the action of sodium on water, or that caustic soda was produced is not a thing visible in the experiment suggested. It is very important for the pupil to distinguish between what he sees and what he infers, and, still more important, to distinguish between what he sees and what *somebody else* infers. Unfortunately, most of our science students learn too much of what somebody else has inferred, usually without a knowledge of the facts from which the inference is drawn, and this inference, which we call a theory, is considered the fundamental fact and the things observed are supposed to hang upon it rather than it upon them. Such a theory is the atomic theory. Examinees in elementary chemistry, when asked to describe a chemical phenomenon, are all too apt to describe it in terms of atoms and molecules, and in such wise to show plainly that their knowledge is of the general kind mentioned above.

It is not uncommon to relegate memory to a very subordinate place in the study of science. We are told that what is required is that the pupil should understand principles, not remember facts. But the concrete is the best introduction to the abstract

and principles are best arrived at through facts, are best illustrated by facts, and are most definitely remembered in connection with facts. It is true that it is more important to train a child to investigate for himself than to give him the result of others' investigation, but the time is too short for him to investigate all he should know. It is in most sciences as it is in geography. The most complete and vivid knowledge of geography is to be got by travel, provided the traveler knows how to observe. But most people have to be content with a knowledge of other countries got at second hand. So in science; in many instances we must rest content with getting our facts second hand, and to get a clear view of the subject and to obtain a firm grasp of the principles, facts must be fixed in the mind. Hence, in an examination paper some questions involving an exercise of memory are not out of place. The examiner should be very careful in setting questions of this kind. The questions asked should not be out of the way ones. They should not in any sense be catch questions, they should be of the kind that any candidate in that grade of examination should know. For instance, in chemistry any pupil ought to learn how hydrogen is prepared or carbon dioxide, or hydrochloric acid, and the properties of these substances, and a question on matters similar to these is well suited to an elementary paper.

The case of carbon dioxide illustrates what I have said above about taking some facts in science second hand. It would not be easy for the pupil to perform an experiment to show that for a given amount of carbon, carbon dioxide contains twice as much oxygen as carbon monoxide; but he should know the fact. Unfortunately, when he does learn the fact, he does not realize that the fact has primarily been learned by experiment, but is liable to talk about atoms and molecules in such a way as to indicate that he considers carbon monoxide and dioxide as specially created by a kind Providence to illustrate the law of multiple proportions. Examinations have a very important function in stimulating the examinee to fix in his mind a number of facts. The student goes over and over his work with the view of making sure that he can tell a straightforward tale to the examiner, and in

doing so finds that the facts gain a definiteness in his own mind which they formerly did not possess.

An examination should not consist entirely of questions of fact. It should be such as to test the examinee's knowledge of underlying principles, and the relation that facts bear to each other. It would be well if some facts that the examinee is not likely to have met could be given and an explanation of them required, care being, of course, taken that the explanation depends upon principles that should be known.

Any little turn of a question that will put the matter in a different light from the ordinary is useful, and the examinee should try to get such a grasp of the fundamental ideas that he will not be caught unawares. There should not be too many questions of this character, for the examinee should not meet too much that is strange, but, on the other hand, the examinee should not have acquired so superficial knowledge of the subject as to be nonplussed by a change in form of question. There are not a few examinees in chemistry who could tell how carbon dioxide and chlorine are made, but would think they were asked something out of the way if requested to give the action of hydrochloric acid on marble and on manganese dioxide.

The science student should endeavor to cultivate accuracy of observation, exactness in the knowledge of facts, a clear insight into the relationship between kindred facts, and an appreciation of the principles involved; the examination should be of such a kind as to determine whether the candidate has made this endeavor and how far he has been successful, and should stimulate the examinee to strive in the best manner for the attainment of a thorough understanding of the work gone over, and for such a mental training as will be of permanent value in future life.—*The School Journal.*

LABORATORY WORK IN PHYSICAL GEOGRAPHY.

BY A. C. NORRIS,

Instructor in Science, East Side High School, Green Bay, Wis.

Much has already been said in this journal in regard to teaching this greatly abused subject. The aim of this article is to present the subject from a somewhat different standpoint. Ten or twelve years ago, when many of us were taking our high school course, we did little or no laboratory work; while today most high schools are doing better work than the smaller colleges did then. This is due to the fact that we have better textbooks, cheaper apparatus and chemicals, and better trained teachers. Physical geography, however, is still in the chaotic state that physics and chemistry were a dozen years ago. Who will come to the front and publish a laboratory guide in physical geography?

The question may be rightly asked, what can first or second year pupils in the high school do along the line of laboratory work which may help them to understand the subject better? The object of this article is to answer this question. The first subject usually treated in our textbooks is that of Elementary Astronomy. A few problems are: To find the latitude and longitude of the school house by means of the sun; to construct a sundial; to lay out the plan of the solar system; to learn the principal constellations; to study an eclipse, if possible.

The subject of the atmosphere offers an excellent opportunity for home and class room work. A few experiments are: Construction of a barometer, thermometer and hydroscope. (A thermometer, weather vane and rain gauge at home, in connection with the school barometer, offer material for a complete weather record, provided the weather vane has a speed indicator); study of atmospheric pressure by means of an air pump and accessories; the study of the different forms of precipitation by means of a

freezing mixture to form ice, ether to form dew, steam to form mist or fog, and wax to make artificial hailstones. Twice the writer has been successful in making a miniature snow storm, by letting cold air enter a moisture-laden room.

No teacher should attempt to teach physical geography without a good collection of rocks and minerals, and the knowledge to use them. If your school has not such a collection, don't draw your next month's salary until you have convinced either pupils or board that you *must* have them. Good collections may be purchased for from $4 to $10. With such a collection as a nucleus, you will have no trouble in getting pupils to bring in local specimens. Don't be content until every pupil knows at least a dozen rocks and minerals. If encouraged, most pupils will know fifty.

Mountain folding, faults, strata, longitudinal and transverse valleys may be illustrated by means of thin plates of paraffin or beeswax. Lava cones may be made of glucose poured on a glass plate, while coal ashes and sand make good materials for ash cones. A miniature volcano is easily made from sand. The top is to be made into a crater, and this filled with equal parts of sugar and potassium chlorate. When ready for an eruption, drop on the top several drops of sulphuric acid. If properly constructed, it will erupt from thirty to fifty seconds.

A few problems that may be shown in regard to rivers, lakes and springs are: Analysis of some medicinal water for soluble salts and gases, such as sulphates, chlorides, iron, lime and hydrogen sulphid. Analysis of some suspected well water for ammonia, chlorides and organic matter. The filling of lakes may be shown by allowing some dirty river water to settle. The action of geysers is illustrated by boiling a saturated solution of brine in a long glass tube. The "bumping" will cause quite violent eruptions.

Enough has been said along the line of class room work. What we need is some manual covering the ground more fully than has been attempted in this article. The enthusiastic teacher will teach much by means of trips to points of geologic interest near the school. Pupils enjoy these outings on Saturdays, the press makes a note of them, and the parents are encouraged and

influenced by them to take a keener interest in our school work. This subject of physical geography is a live one, needs only a little enthusiasm and tact to make it the most valuable of all the sciences. The writer would be pleased to hear from any one who has done real systematic work in this subject, and who has suggestions or criticisms to offer.

AN EXPERIMENTAL ILLUSTRATION OF OSMOTIC PRESSURE.

BY C. F. ADAMS.

Head of Department of Physics and Chemistry, Central High School, Detroit, Mich.

Doubtless many teachers of physics like myself have had much trouble in illustrating osmosis by the methods usually given in the textbooks and the following experiment may be of interest to them.

Acting upon a suggestion of Dr. L. Murbach, given in the November number of SCHOOL SCIENCE, page 300, I secured a large, sound carrot. In the axis of this by means of a carpenter's bit I bored a hole about 2.5 cm. in diameter and 10 cm. deep. I also peeled the carrot up to its crown. The hole was then nearly filled with sugar and water added to within a centimeter of the top. To close the hole a two-hole rubber stopper was used, in one hole of which was inserted a piece of barometer tubing about 2 m. long and having a bore of about 1.5 mm. After the stopper with the long tube was firmly driven into the top of the carrot, the other hole in the stopper was closed by a glass plug. It was then supported, by means of a clamp, on a ring stand in a beaker of water so that all but the top was immersed in the liquid. Two hours and a half after it was first set up the liquid had reached the top of the tube. At four o'clock in the afternoon the carrot was again filled and set up and the glass tube lengthened by con-

necting another glass tube to it by means of a piece of rubber tubing. The bore of the upper tube was larger than the lower one and hence the rate at which the liquid rose through it was much less than in the lower one. The top of the tube was 308 cm. above the water in the beaker. At 8 o'clock the next morning the tube was full and the current in it was still upward, while on the outside of it there was a trail of thick syrup, showing that it had run over during the night. The liquid forced up the tube was a thick syrup with a density possibly of 2 g. per c c., hence the pressure here shown is about twice as great as it would have been if pure water had been raised to the same height, but only a fraction of the total osmotic pressure such a solution of sugar is capable of producing.

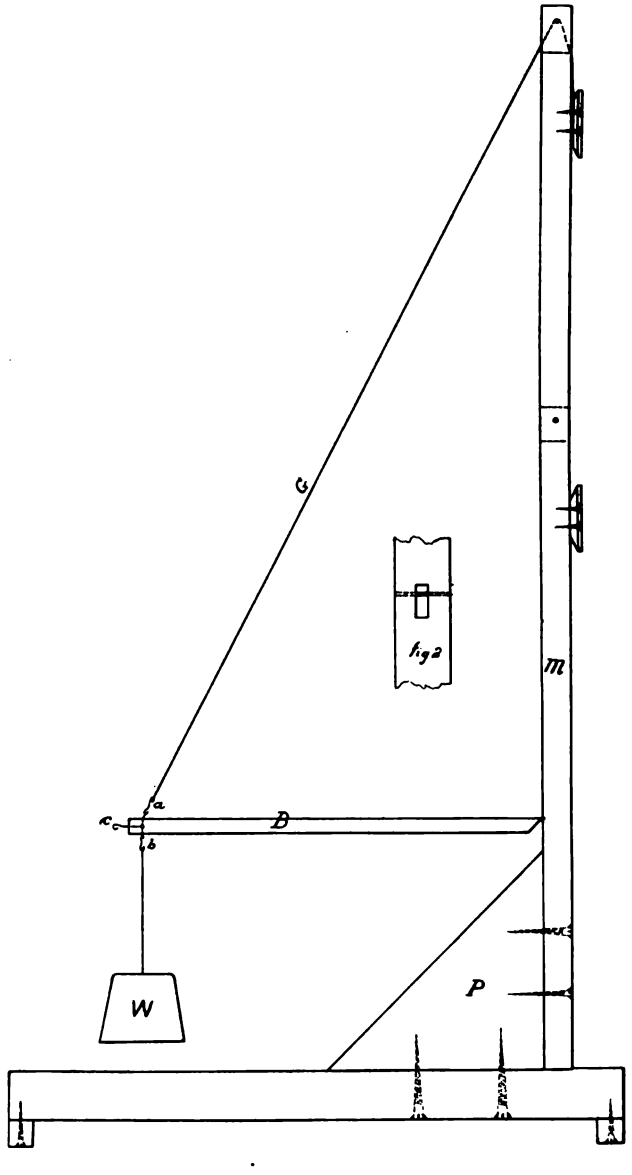
Perhaps some of the readers of SCHOOL SCIENCE may be sufficiently interested in this experiment to test its possibilities still further. I have tried other vegetables besides the carrot but none of them seemed to be so well adapted for the purpose as that.

AN EXPERIMENT IN RESOLUTION OF FORCES.

BY E. C. WOODRUFF.

Instructor in Physics, La Grange (Ill.) High School.

Composition and resolution of forces seems to be a part of physics that puzzles the majority of pupils. Their bewildered state of mind is probably due largely to their lack of constructive imagination. Among the other functions of the high school laboratory the development of a constructive imagination seems to be one of the most important. Hence the more intimately we can deal in the laboratory with difficult questions that involve this faculty the better. The usual experiments with three spring balances cover the questions in composition of forces satisfactorily. But so far no experiment seems to bring out the points involved in the resolution of a force. Of course every case of static composition can and should be interpreted also as a case in resolution. Still even this will leave something to be desired. An experiment where the question of resolution is the leading question would seem to be


C
fig 2
m
a
B
c
b
W
P

especially desirable. Such an experiment is the subject of this article. The experiment consists in investigating the stresses of extension and compression in a simple crane or a tie-bracket. The load constitutes a single known vertical force to be resolved into a compression along the boom and an extension along the tie-bar or whatever takes its place.

The problem is to be solved in three ways: (1) Trigonometrically and (2) graphically by measuring the necessary sides and angles of the triangle formed by the three forces, and (3) by substituting a dynamometer for the different members of the crane, one at a time, and taking the readings.

The crane is constructed as follows: A heavy base supports the mast *M*. The mast is 2x4 cm. in cross-section and 80 cm. high. It is firmly braced by the triangular piece *P*. The boom *B* is 30 cm. long and 1x2 cm. in section at the mast-end, tapering outward to 1^2 cm. The mast-end of the boom is beveled as shown and fits into very shallow notches in the mast. The outer end is furnished with three loops of strong flexible cord, taking the directions *a*, *b*, and *c*. *b* supports the weight *W* which may be a scale-pan and weights, *a* fastens to the guy rope *G*, and *c* furnishes means of attachment for a dynamometer. The notches in the mast are made 20 and 30 cm. from the base. 15 cm. above the upper notch a slot is cut through the mast as shown in Fig. 2, and a brad is driven across the slot to furnish a bearing for the guy-rope. 30 cm. farther up, at the top of the mast, is placed a similar bearing. On the back of the mast are fastened cleats to hold the free end of the guy-rope when necessary.

The experimental operations are as follows:

(1) The apparatus is set up as in the figure with a weight of perhaps one kilo, the guy-rope over the upper bearing, and the boom in the lower notch, adjusted so as to form a right angle with the mast. The sides of the force-triangle will then be 30 cm., 60 cm., and $\sqrt{60^2+30^2}$ cm., or if the right angle is not exact the sides may be measured.

(2) A dynamometer is attached at *c* and pulled horizontally until the boom starts to drop. The maximum reading equals the compression along the boom.

(3) The boom is replaced, the guy unfastened from the cleat,

the dynamometer fastened to a loop in the guy and pulled in, in the proper direction, until the boom is supported as at first. The reading is then the tension of the guy.

The three ways of obtaining the stresses in boom and guy should agree fairly well, success depending to a great degree on the operator. This makes the experiment all the more valuable pedagogically. In the case cited the stress of the boom and the load should have been related to each other as 1 is to 2. Now by using the proper combination of bearing and notch the 60 cm. of the first case becomes successively 45, 30, and 15 cm., and the strain on the guy increases very rapidly. By shaping the notches in the mast properly, cylindrical-shape, the boom may be used at other angles than right angles with the mast with profit.

Before this experiment was originated one normally bright pupil had some difficulty in believing that the strain on a brace or a guy could be greater than the load, *e. g.*, how the strain on a clothes-line might be enormous with a comparatively light load. His difficulty vanished when faced by empirical evidence. This experiment has to a considerable degree the power to direct a pupil's attention to the applications of the principle involved that he daily meets ordinarily with unseeing eyes, such as telegraph, telephone, and trolley lines, street lamps, clothes lines, steam derricks, shovels, dredges, and cranes in general.

A more elaborate form of guyed crane is also being used in the writer's laboratory. One where the boom has a bearing on the base board and is placed at any angle. The mast is loosely stepped near the boom's bearing and is guyed from behind. Any concurrent three of the half dozen members are investigated at a time, the others remaining constant. The apparatus is in fact a hoisting derrick, fitted with the proper pulleys, etc., and proves of much interest to the pupils. The experiment takes no longer than more conventional ones and teaches many things.

A SIMPLE METHOD OF MEASURING THE EARTH'S MAGNETIC FIELD.

BY HERMAN D. STEARNS.

Associate Professor of Physics, Leland Stanford University.

In this paper I shall indicate a method by which the better students in a high-school class many measure the horizontal component of the earth's magnetic field with sufficient accuracy to make it instructive, and which is so simple that they may understand every step in the process. I am not aware that it has been described before. I shall present the method in the form of a laboratory exercise.

Select two knitting needles nearly alike. Magnetize both so that the poles shall be very near the ends and determine the position of the poles as carefully as possible. Call one needle A and the other B. Let the pole strength of A be m, and let that of B be m'. Let the horizontal component of the earth's magnetic field be H.

FIRST POSITION.

Suspend A by a long fine silk thread so that it is free to move about its center in a horizontal plane. Allow it to come to rest indicating the direction of the magnetic meridian.

Turn A in the horizontal plane until it is perpendicular to the magnetic meridian. Hold it in this position by means of a very fine silk fiber about 10 cm. long, one end of the fiber being fastened by soft wax to one pole of A, the other end being fastened at the same height to a movable block of wood. Move the block until the fiber is perpendicular to the needle, as in Fig. 1.

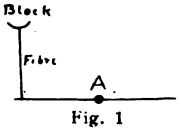


Fig. 1

The needle A is now at rest under the action of three forces, as shown in Fig. 2. The mechanical force F acting through the fiber on one pole of the needle is exactly balanced by the two magnetic forces acting on the poles of the needle, which are due to the horizontal component of the earth's magnetic field. If the poles are equally distant from the center of the needle we have

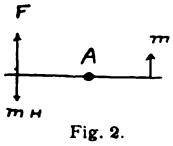


Fig. 2.

(1) $$F = 2\ m\ H$$

To measure F, slip a wire weighing about 10 milligrams over the fiber midway between the block and the needle and move the block nearer the needle until the position of the needle is the same as before the weight was added. The force F is now unchanged, and can be computed in dynes by a simple resolution of the forces shown in Fig. 3, if (a) and (b) are carefully measured.

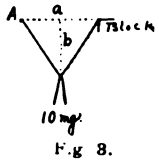


Fig. 3.

SECOND POSITION.

Remove the needle A and suspend the neeedle B as A was suspended at first. Hold B in the same position as A in Fig. 1, but instead of a fiber use the repulsion between one pole of B and a like pole of A, as shown in Fig. 4.

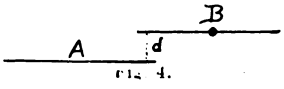
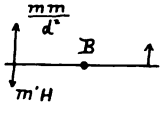


Fig. 4.

A may be supported on a block of wood. It should be parallel to B, and at the same height, and should be moved in the direction of its length until the adjacent poles of the two needles are opposite one another and produce the maximum repulsion. Call the distance between the poles (d) and measure it as accurately as possible in centimeters.



The needle B is now under the action of the forces indicated in Fig. 5, and the equation is:

$$\frac{mm'}{d^2} = 2\ m'\ H$$

or

(2) $$\frac{m}{d^2} = 2\ H$$

From equations (1) and (2) find the values of H and m and interpret the meaning of these values.

A study of Figs. 4 and 5 will show that equation (2) will not apply if (d) is too large. If (d) differs greatly from 4 cm. for needles about 22 cm. long, change the pole strength of A until a proper value is reached and repeat the experiment.

Metrology.*

THE RECENT METRIC BILL.

BY RUFUS P. WILLIAMS.

A consistent metricist is sure to take issue with some points of House of Representatives Bill 123, now before Congress. The bill is as follows:

Be it enacted, That on and after the first day of January, nineteen hundred and four, all the Departments of the Government of the United States, in the transaction of all business requiring the use of weight and measurement, except in completing the survey of public lands, shall employ and use only the weights and measures of the metric system; and on and after the first day of January, nineteen hundred and seven, the weights and measures of the metric system shall be the legal standard weights and measures of and in the United States.

Of the two separate parts, government usage and legal standard weights and measures, the former is the dominant issue. While any of the executive departments of the government have a legal right to use the metric system, and while several of them do use it, there will be no universal use by the departments until a compulsory law is enacted. This general feature of the bill is to be commended as a first step in metric reform. Three items in this proposed legislation, however, merit especial consideration. 1. The public land survey. 2. The date for government usage. 3. The legal standard clause.

1. The real necessity for making an exception of public land measurement is not apparent, but it leads one to conclude that surveying stands so far apart from other crafts requiring measurement that it should have special consideration. Such is not really the case. The chief opponents of the metric system have not been surveyors or civil engineers. These have more often been friendly to the reform. As far back as 1875 the Boston Society of Civil Engineers passed rosolutions favorable to the system, and the United States Coast and Geodetic Survey has used it for the best part of a hundred years, in fact from its foundation.

* Communications for the Department of Metrology should be sent to Rufus P Williams, North Cambridge, Mass.

Judging from the character of the opposition among the various trades one would think that the naval department and the machine shops of the government should be excepted if anything is, when one takes into account the screw threads, the fittings of all adjustable parts, and the machinery used in making the same.

Aside from government works, machinists and mechanical engineers have been the greatest opponents of the system, for it is claimed that with them the readjustment would be more difficult and expensive than in other lines of work.

Or, if exceptions are to be made, has not the Customs department some claim for consideration, since all laws pertaining to customs duties are framed for yards, gallons, bushels, pounds, etc., and all these must be changed in case the department uses the metric system exclusively?

The Postal department, too, might well ask to be exempted and allowed to run for another hundred years on ounces and pounds. If any exception is to be made why not except all the departments and leave things as they are? We believe there is no need of excepting the public lands, or anything else. If the reform is to be beneficial, let it benefit all at the same time.

The reason for inserting the exception in the bill appears to be that in 1895-6, when the question was before the Committee, certain influential men, as the Director of the Geological Surveys, and the Commissioner of the Land Office, believing in the merits of the metric system in general but wishing to retain the old one in their particular field, made it appear that the "people of the United States have become so accustomed by long usage to think of all land measurements in terms of the English system of miles, rods, links, chains, acres, etc., that it will be practically impossible to persuade them to adopt the metric system for land measurements," etc., all of which might be said with equal cogency in reference to any other department. The influence of these men carried the day and secured the absurd exception, which has been continued in every subsequent bill.

The bill reads . . . "except in completing the survey of the public lands"—as though the survey were nearly finished. In truth we shall always be surveying so long as the government

continues to own lands, especially if Uncle Sam goes on—as he is likely to do—acquiring more and more real estate. The land department will then have the anomaly, after everybody else is using the metric system, of antiquated measures.

When France adopted the metric system she made no exception of land measurements. The very foundation of the system was in surveying. Germany, Sweden and other nations, in enacting general metric laws, did not make partial exceptions. At best the change has got to bring some temporary inconvenience to every sort of business. But this inconvenience will be far less than the opponents of the measure set forth. The longer the change to a better system is put off, the harder will it be to make it. Probably the best time for the change was in 1821 when Adams—who was a real believer in the merits of the system—made his report. Could he have looked ahead 50 years, our generation would have known no other system than the metric.

2. The Shafroth bill, introduced Jan. 10, 1900, made the date for government usage Jan. 1, 1901, and the legal standard clause Jan. 1, 1902. These dates have been successively set forward until they now stand respectively Jan. 1, 1904, and Jan. 1, 1907. If a metric bill requiring government usage can be passed, it is debatable how far ahead such compulsion ought to be placed for the best interests of all concerned. The probability of passing such a bill must necessarily be much influenced by the date. If placed 25 or 50 years from now there would likely be little or no opposition, but the object of such legislation would be lost to the present generation. A time limit sufficient to enable all departments to prepare for the change, to supply the new implements of measuring, to train the employees in their use, is all that seems necessary. A period of five years would seem to be ample and three might easily suffice. In the event of a longer time little or no thought would be given the subject until the time for actual use became nearer. In Germany some 3½ years elapsed between the enactment of the law and its compulsory use, with two years of permissive use intervening. During this interval everybody had become accustomed to the new measurements and when the time came for all to change, nobody was left to be compelled. Yet this was an instance in which not the government officials alone, but

the whole people, had to use the new system. Three or five years therefore seem a sufficient time for inaugurating a change in governmental departments, unless a longer interval is set for the express purpose of winning adherents to the cause.

3. The double dates of the bill—Jan. 1, 1904, for government usage, and Jan. 1, 1907, for making metric measures legal standard measures are, to say the least, incongruous. We are ready to endorse, for this part of the bill, the resolutions—which were not passed—of the Mechanical Engineers at their last meeting, that the bill was "simply absurd." If there is necessity for the last clause at all, then the two events should bear the same date. Consider what legal entanglements might arise with double dates. (1) Are all the departments of government—the public lands excepted—to be compelled by law to use weights and measures three years before they are made legal?

(2) Is this clause a confession that the weights and measures of the metric system are not now legal? The law of July 28, 1866, made them legal and they are the only ones that have been legalized except for coinage purposes. The United States courts in rendering any decision must by this law, in absence of any other legal standard, refer all other weights and measures to the metric.

(3) Are all other weights and measures to be illegal after Jan. 1, 1907? And, if so, are the public lands to be surveyed by illegal measures? This question of what is to take place Jan. 1, 1907, has given rise to more controversy than all the rest of the bill, and has placed in the hands of opponents of reform a powerful cudgel. The National Association of Manufacturers attacked it, claiming that it meant compulsory use for all the people in every line of business. The Society of Mechanical Engineers did the same. Although it was explained by Mr. Shafroth, the maker of the bill, that that was not its purpose, and although Attorney General Knox declared that if such was its intent it could not be enforced, and though editorials in leading newspapers tried to set the matter right, yet the effect on the rank and file of those who read it was that of force, and they resisted. We believe that this last clause of the bill lost the metric system many adherents and raised an opposition that would not have existed against the main proposition.

What then was the real purpose of this ambiguous clause?

Mr. Shafroth states that its object is "to require all proceedings in court and all judgments in court, whether United States or state courts, to be expressed in the weights and measures of the metric system. It does not invalidate contracts made even after that time in other weights and measures, but the pleadings filed in cases, when the same relate to quantities and lengths, must be expressed in the weights and measures of the metric system."

According to the author of the bill, then, there are two distinct reasons for the obnoxious clause—pleadings and judgments in the courts (1) of the United States, (2) of the various states. The most that can be said in its favor as regards the first is that it strengthens the legality, makes what is already legal more legal. As every state has its own laws and usages concerning weights and measures, there might not be a case in 50 years coming before the United States courts in which the principle would be involved. The one most likely to come up would seem to be the land survey, which by this same bill is exempted from the category of legality.

As regards the state courts where questions of measurement and weight are constantly to be settled, it seems very doubtful whether the words "of and in the United States" would be construed as setting aside all the laws concerning weights and measures in all the states of the Union.

The bill under discussion was introduced by Hon. John F. Shafroth, of Colorado, Dec. 2, 1901, and was reported April 21, 1902. It has not yet been assigned on the House calendar, and is likely to meet the fate of its predecessors, there being not the slightest chance of its reaching the Senate even were it to pass the House. The most that its ardent advocates have hoped is to get a show of hands and find how the members of the House stand on the question. In the English Parliament the opinion of every member is known, but Congress has had no such canvass and the public is in ignorance of its attitude on the metric question

The Committee on Coinage, Weights and Measures, secured the most valuable array of facts and opinions in favor of the metric system that has yet been published, and issued an excellent report.

The present bill having been dissected, it is in order to ask what are the elements of a bill likely to have least criticism? In matters of reform "one thing at a time" is a good rule. What is

needed is a bill that is not ambiguous, that holds to the one point of government usage, and one that every man who knows aught of the metric system can ask his Representative in Congress to vote for or against. How would this do?

Be it enacted, etc.:

That on and after the first day of January, 1908, all the departments of the government of the United States, in the transaction of all business requiring the use of weights and measurements, shall employ and use only the weights and measures of the metric system.

NOTE.

Action of Mechanical Engineers on the Metric System.—After a spirited debate for and against the metric system by members of the American Society of Mechanical Engineers at their 46th semi-annual meeting in New York, December 3-5, it was voted, 34 to 29, "that the society should form the component part of a commission or committee to prepare the arguments on both sides of the metric question." It was also voted that "a letter ballot should be taken to obtain the sense of the members, individually, on the question, first, of the policy of making the metric system obligatory on the governmental departments, and second, on the question of making that system more obligatory than it now is on the community serving the governmental departments." A resolution so worded as to commit the society to a definite opposition to the policy of the system was lost by a vote of 37 to 32. Previous to the meeting, F. A. Halsey, associate editor of the American Machinist, had prepared and issued in advance to members an elaborate document of 48 printed pages in violent opposition to the metric system, and Sidney A Reeve, of Worcester (Mass.) Polytechnic Institute, had sent to members a 16-page article on the merits of the duodecimal system. On the other hand, a friend of the metric system had issued to each of the 3,000 members a copy of the Textile World canvass, which showed a majority in favor of the adoption of the system, and a copy of a recent reprint from SCHOOL SCIENCE, "Partial Use of the Decimal System Thirty-five Years After Legalization."

R. P. W.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

CHEMISTRY.

Solid Hydrogen Peroxide.—When 95 per cent hydrogen peroxide is exposed to a temperature of —23°, it becomes solid, and when a trace of this solid is introduced into more of the liquid peroxide reduced to a temperature of only about 9°, large, clear prisms of the solid separate out. By pouring off the mother liquor and crystallizing again, a 100 per cent peroxide is obtained. By this process of infection with a trace of a crystal, solutions containing only 80 per cent of the peroxide may be readily made to crystallize. The pure peroxide, when brought in contact with even a very small amount of platinum black or manganese dioxide powder, is decomposed with explosive violence. Magnesium and lead in powdered form burn with great brilliancy, sending off showers of sparks. Wool or a moist sponge are immediately set on fire by a few drops of the anhydrous peroxide. As a disinfectant, the pure peroxide promises much. It is an ideal antiseptic, as it does not introduce any foreign matter into a wound and decomposes only into oxygen and hydrogen. In a state of purity, the peroxide can be transported without danger.

Zeitschrift für angewandte Chemie XV., 26, p. 642. H. STAEDEL.

An Apparently Safe Way to Mix Hydrogen and Chlorine.—Second in importance to the direct synthesis of water as a demonstration experiment is the synthesis of hydrochloric acid. Such methods as the one where a bottle full of the proper mixture of gases is thrown from a window into the sunshine bring out but a few of the points that need to be demonstrated. For that matter, even the more elegant method given by Newth shows little more than that a hydrogen-chlorine mixture is exploded by light. No doubt the suggestions to be here given have been tried before. Still, there seems to be no record of the degree of success that may have been attained. Perhaps the success of the method as used last fall was accidental and perhaps the experiment is not safe. In any case it might be desirable to proceed with caution.

Two thick, wide mouthed bottles were filled, one with hydrogen by displacement of water, and the other with chlorine by displacement of air. They were placed mouth to mouth, but separated by glass plates and put in the sunshine, the hydrogen bottle on top. The plates were then removed. The yellow color of the chlorine gradually disappeared and the bottles became filled with dense hydrochloric acid fumes. The reaction was quiet and progressive, but not complete. After ten minutes the bottles were held, one at a time, mouth to a Bunsen burner. The

resulting explosions were harmless, but very violent, much more violent than the same quantity of an explosive mixture of hydrogen and oxygen would have produced. Six or eight points were thus demonstrated with a minimum amount of trouble, but with a rather severe nervous strain, especially on the first occasion. The chlorine was made from potassium chlorate and hydrochloric acid. Possibly pure chlorine might have been more or less violent.

E. C. Woodruff.

Making Pure Oxygen.—If oxygen is made in a metal retort, it is a good plan to put in a few cc. of water. The water will boil before oxygen comes off. As soon as the steam comes free from air, the delivery tube may be connected to the gasometer. The oxygen will then come whenever it is ready, without any further attention or trouble, and will generally be over 99 per cent pure. This is not only a good method of getting oxygen for eudiometer and other more or less quantitative work, but it is the best when preparing for other purposes, since it is easier to carry on than if steam is not used, and it avoids the waste which is inevitable where the gas is used to sweep air out of the retort.

W. F. White.

PHYSICS.

Electrolysis of a Salt.—Place in the bottom of U-tube about a tablespoonful of clean sand and fill the tube with a moderately strong solution of sodium sulphate previously prepared by dissolving the salt in water, adding a few drops of phenolphthalein, and then a very dilute solution of sodium hydroxide until the solution becomes the *faintest* pink. Support the tube on a ring-stand and thrust the terminals of a battery into its branches. Results will be obtained in a few moments with three cells of a bichromate battery of 1.1 volts each, connected in series.

Holland, Mich. M. E. Dick.

The Study of the Voltaic Cell may be well introduced by means of the following experiment: Strips of sheet zinc and copper are cut of a size about 2 to 3 mm. wide and 60 to 80 mm. long. Two slits are cut in the side of a cork deep enough to hold the strips firmly 8 to 10 mm. apart. A copper and a zinc strip are inserted in these slits, the cork being placed at about one-third of the length of the strips. The longer ends of the zinc strips are amalgamated by rubbing them with a drop of mercury after they have been moistened with dilute sulphuric acid Two such pieces of apparatus are floated in dilute sulphuric acid in a jar or tumbler, thus forming two open voltaic elements. If one of these

be closed by bending the top of the copper strip over so that it will come in contact with the zinc strip, hydrogen is evolved at the copper plate and in about a quarter of an hour the zinc plate is completely dissolved. The open cell, however, does not undergo any change. The experiment is especially valuable in that it shows very well the production of electrical energy at the expense of chemical energy.

Natur und Schule, I, p. 370. E. GRIMSEHL.

Battery for Strong Currents.—For those who have no storage battery and can not well afford the expense of often renewing large Edison Lalande cells, the best battery for strong, continued currents is the Bunsen. A large part of the trouble and expense of Bunsen cells as they are ordinarily used results from the necessity of providing and caring for the amalgamation of the zincs. If salt solution is used instead of sulphuric acid the zincs do not need amalgamation. Such a battery, with salt and nitric acid for the two liquids, is theoretically very much cheaper in proportion to the energy available than any other cell in common use. An odor of chlorine would be expected from such a combination, but there seems to be none whatever. There is a slight odor of nitrous fumes, and if this should prove objectionable, the battery can be removed to another room, or boxed in, or chromic acid may be used in place of the nitric.

W. T. WHITE.

GEOLOGY.

The Geological Society of America has just issued pages 377-474 of Volume 13, as a separate brochure under the title "Catalogue of Photographs belonging to the Geological Society of America." The collected photographs now number 1,418, after a careful revision and rejection of all such as do not show clearly some geological process or phenomenon. The list is arranged by states and miscellaneous, and a separate list is arranged according to subject, as Ant Hills, Bad Lands, Beach Deposits, etc. The catalogue contains photographs largely from negatives in the collection of the United States Geological Survey. After each title is given in parenthesis the negative number of the United States Survey, and prints and photographs may be ordered from the Survey at the following prices:

Size.				Mounted.	Unmounted.
11	by 14	inches	.....	35 cents	30 cents
8	by 10	inches	.....	25 cents	20 cents
6½	by 8½	inches	.....	20 cents	15 cents
5	by 7	or 8 inches	.....	15 cents	12 cents
4	by 5	inches	.....	10 cents	8 cents

Lantern slides are furnished through the Survey at 50 cents each, or 45 cents if 100 or more are ordered. This makes available the large number of pictures collected by the United States Survey in the best form, for while the catalogue of the Geological Society does not contain all the pictures of the Survey, it contains practically all that are valuable as illustrating either geological, physiographical or geographical subjects. Pictures or slides should be ordered through the director of the United States Geological Survey.

The catalogue, if not otherwise available, may be purchased from the secretary of the Geological Society of America, Professor H. L. Fairchild, Rochester, N. Y.

E. C C.

Book Reviews.

Alembic Club Reprints—No. 16. Papers on Etherification and on the Constitution of Salts. By ALEXANDER W. WILLIAMSON (1850-1856.) 13x19 cm., 62 pages. The University of Chicago Press. 1902. 40 cents.

"The papers reprinted here form a group of great interest to the student of the historical progress of chemistry. They date from a period at which the development of synthetic organic chemistry was only beginning to occupy the attention of chemists to any considerable extent, and they deal with a number of questions which were matters of controversy at that period. The most important of these questions were undoubtedly those concerning the theory of etherification, and the true relationship of alcohol and ether to each other, and both to water. It is in regard to his elucidation of these questions in particular that the name of their distinguished author, as that of one of the pioneers in the foundation of modern organic chemistry, will always be ultimately connected with the history of chemistry."

While these papers are probably too difficult for secondary school students, yet chemistry teachers will profit by reading them and should see to it that this reprint is in their libraries. Note should be made of the reduced price (now 40 cents) of these reprints and that the American publisher is the University of Chicago Press.

C. E. L.

Lectures on the History of the Development of Chemistry Since the Time of Lavoisier. By A. LADENBURG. Translated from the Second German edition by LEONARD DOBBIN. (With additions and corrections by the author). 14x20 cm., xvi and 373 pages. The University of Chicago Press. 1902. $1.75.

The reviewer has already in a review of Mach's *Science of Mechanics* (Dec., 1902, number, page 362) called attention to the importance of historical study on the part of the teacher of science. While the present book is written in quite a different vein from that by Mach, yet what was said in the review of the latter book can well apply to this one also. It is a significant fact that this English translation appears about thirty years after the first German edition; this should not be interpreted as a tardy appreciation of the excellencies of the book, but should rather be a proof of the permanent value of the author's presentation of the subject.

The book in its English dress has been amplified by the addition of two lectures which brings it quite up-to-date. The translation seems to be very smooth and the mechanical execution of the book is commendable.

Every teacher of chemistry should have the book in his library; he will find it both instructive and inspiring reading.

C. E. L.

Nature Study for Grammar Grades. By WILBUR S. JACKMAN, A. B. 13x20.7 cm. 407 pages. The Macmillan Company, New York. $1.00 net.

Few books on nature study are of greater interest to the progressive grammar grade teacher than this one. Although it is primarily a child's text-book it will also be a valuable addition to any teacher's library.

The aim of the book, as the author states it, is to outline some of the problems within the child's comprehension which arise from a thoughtful study of nature, and to offer suggestions which may aid in their solution. Every topic is therefore resolved into queries under each of which are suggestive points for consideration. Thus the chapter on "Autumnal and Winter Habits of Animals and Plants" opens with the question: "In what way does the gradual lowering of temperature affect animals?" "Consider: *a*) the food supply; *b*) necessity for

bodily protection; *c*) chief conditions that give rise to migration; *d*) chief conditions which give rise to hibernation; *e*) chief conditions which enable animals to remain active in their usual haunts during the winter season, etc."

In general directions for field work, the making of apparatus, or the necessary observations precede the questions. Then follows number work involving the quantitative side of the work, directions for drawing and painting various phases of the specimens and occasionally the embodiment of results in a tabulated or an essay form. The teacher is supposed to assign a topic to his class and then give them time for individual investigation. After experimentation the child reports in a class period the results obtained.

It is hard to imagine the child investigating the topics of food, minerals, work and energy without the direction or oversight of the teacher. In many of our city schools the necessary amount of field work and the proper equipment would be serious problems for the grade teacher. In many cases the teacher with some ingenuity can substitute inexpensive, home-made apparatus, but accurate scales, retort stands, barometers, glass and rubber tubing are not easily obtained or satisfactorily dispensed with.

While the reviewer heartily approves of the book, yet portions of the topics of light, sound, landscapes and of germination seem too difficult for the child.

The method of work in this book is especially worthy of attention. It approaches much more nearly that of the investigator than does the older method of teaching nature study. It requires independent work, encourages unbiased results and is suggestive to both *child* and teacher. It describes many important experiments and outlines much exact, quantitative work within the child's power. The value of the chapters that deal with soil, distribution of seeds, heat, astronomy, meteorology, and spring studies can hardly be overestimated. There are also topics on proper ventilation, heating, foods and the relation of food to work.

GERTRUDE A. GILLMORE, Teacher of Nature Study, Washington Normal, Detroit, Mich.

Reports of Meetings.

THE NEW YORK PHYSICS CLUB.

The twentieth meeting of the New York Physics Club was held in Pratt Institute, Brooklyn, on December 13, 1902, with Mr. J. M. Jameson, President, in the chair. After an inspection of the laboratories, the meet-

ing was opened by Mr. E. D. Pierce, for the Current Events Committee, who made a report outlining a plan of work and appointing different members of the club to be responsible for items of interest in designated journals of professional and scientific character. It is thus hoped to keep track of current events in the scientific world.

Mr. L. V. Case for the Text Book Committee presented a careful review of three books: (1) The History of Mechanics, by Dr Ernest Mach (Open Court Publishing Co., Chicago); (2) Elementary Electricity and Magnetism, by D. C. & J. P. Jackson (MacMillan & Co.), and (3) Mechanics, Molecular Physics and Heat, by Dr. Milliken of the University of Chicago. (Scott, Foresman & Co.)

Dr. E. R. Von Nardroff, of the Erasmus Hall High School, for the Apparatus Committee stated that the movement to add a second elective year in physics to the course of study in the high schools of Greater New York was gaining ground and that the matter was to be discussed at the coming meeting of the New York State Science Teachers' Association. He urged the necessity of keeping in mind and preparing a suitable list of experiments for such a course. Dr. Von Nardroff showed three pieces of apparatus adapted for such advanced experiments. The first was a calorimeter of large size with electrical connections, coil, thermometer and stirrer for finding the heat equivalent of one joulé. The second piece shown was an instrument made by Kohl of Bonn, consisting of a combined whirling table, friction cup for holding water, index arm for weight attachment and thermometer, the whole intended to furnish a comparatively simple method for determining the mechanical equivalent of heat. The third piece shown was a simple form of electric projective lantern with detachable parts to be put into the pupil's hands and which they were expected to learn to operate.

The club then assembled in the large lecture room of Pratt Institute and listened to an interesting and instructive illustrated lecture by Prof. R. W. Wood of Johns Hopkins University upon "The Instantaneous Photography of Invisible Objects." Prof. Wood said in part that objects might be invisible from three causes, *first*, because being in total darkness they neither received nor emitted rays to the eye. This class he did not further discuss. *Second*, objects may be invisible on account of their rapid motion. This class has been rendered visible by methods of instantaneous photography. Series of illustrations were presented showing how a cat dropped back downward, turned over and landed on her feet, the waves in the air made by a bullet in motion through the air; by a bullet as it crashed through a pane of glass; a drop of water falling into milk with the form of the return splash; a drop of mercury falling on a plate of glass; a charge of shot in the air. Prof. Wood showed a series of photographs taken by himself illustrating the form of a sound wave under different conditions, some of which were the following; when reflected from

a plane surface; from curved surfaces of different shapes; from two curved surfaces; from a row of steps; when refracted by a CO_2 lens; when diffracted by a grating. In illustrating the third class of invisible objects or those which emit rays which lie outside the limits of the visible spectrum, two photographs were shown, one taken by yellow light, the other by light waves wholly invisible to the eye. The latter picture was taken by placing over the lens of the camera a compound screen consisting of plates of colored glass which cut off the red and violet rays and of a gelatine film stained with nitroso-dimethyl-aniline, which cuts off the heat rays, but permits the ultra-violet rays to pass. This screen Prof. Wood discovered. When the nitroso-dimethyl-aniline is fused between glass plates placed at an angle with each other it may be used as a prism. It forms a spectrum rich in ultra-violet rays and much longer than that formed by a quartz prism. It cuts off the visible rays except a little red and violet. When the screen referred to is placed in front of the lantern provided with the arc light, a very small trace of green can be detected by the naked eye. That ultra-violet rays are present is proved by the fluorescence of a crystal of uranium nitrate.

Reported by R. H CORNISH.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

ABSTRACT OF PROCEEDINGS OF PHYSICAL SCIENCE SECTION.

The programme of Section A (physics and chemistry) of the New York State Science Teachers' Association, at the last meeting, was devoted wholly to physics. It has been thought best to concentrate all effort on one subject and thus secure practical results rather than scatter and get merely a smattering. Two meetings of the section were held in one of the lecture rooms of the Syracuse University Medical College, and both sessions were well attended by high school and normal school teachers and by college professors. Quite a large number of academic principals, in attendance at their association meeting, patronized the section meeting.

The first session of the section was held at 4 p. m., Tuesday, December 30, 1902. Mr. E. R. von Nardroff, of Erasmus Hall High School, Brooklyn, gave a strong address on "A Second Year's Course in Physics for the High School," in which he showed the necessity for extending the good work begun by the association in its physics syllabus, and the impossibility of completion, in the fullest sense of the word, of secondary school physics by approved methods in one year. Wireless telegraphy, specific heat, the spectroscope and the deeper parts of physics

are best understood after a year's training in the more elementary work.

Mr. H. L. F. Morse of Troy, High School, Mr. L. V. Case of the Washington Irving High School, Tarrytown, and Mr. Charles N. Cobb of the Regents' Office led in the interesting and vigorous discussion which followed. That the course suggested was desirable was admitted by all, and, on motion, a committee was appointed to prepare a syllabus for a second year's course in physics, the committee to report at the meeting next December. Mr. E. R. von Nardroff of Erasmus Hall High School, Brooklyn, Mr. R. H. Kittredge of Schenectady High School, Mr. Frank Rollins of Bronx High School, New York, Mr. Charles N. Cobb of the Regents' Office, Albany, and Mr. O. C. Kenyon of Syracuse High School were appointed as such committee.

At the second session of the section, held at 9:30 the next morning, Mr. George M. Turner, of Masten Park High School, Buffalo, the secretary of the section, read a paper prepared by Mr. O. C. Kenyon, of the Syracuse High School, who was unable to be present by reason of injury, resulting from a fall in his new laboratory. The paper was on "The Physics Machine Shop in Secondary Schools: Its Value, Equipment and Management. How to Use It and Benefit a Class of Pupils in the Making and Repairing of Physical Apparatus." The paper was a very helpful and detailed outline of a course in manual training, to be taken in connection with science in secondary schools. Mr. L. V. Case of Tarrytown High School and Mr. William M. Bennett of Rochester High School added much to the subject from their own personal experience. Several creditable pieces of home-made apparatus were exhibited.

Reported by E R. WHITNEY, Chairman.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

ABSTRACT OF PROCEEDINGS OF THE BIOLOGICAL SECTION.

The first paper was on "The Value of Research Work in Botany," by Chairman J. E. Kirkwood, of Syracuse University. It outlined the uses of research in the preparation of a science teacher of the secondary schools and colleges. Among other aspects of the subject, it noted a tendency in some colleges to so increase the amount of research work required that the general preparation in botany was made inadequate to the teacher's needs. Three necessary qualities of a successful teacher were pointed out: (1) A teaching personality, (2) scholarship, and (3) proficiency in the arts of teaching. Of these, the teaching personality is an innate quality and can not be acquired; therefore is outside the in-

fluence of research work. It was held that it was hardly possible to gain a thorough scholarship by research in narrow lines as required for the doctorate. Hence, a thorough grounding in the subject should be attained before research is entered upon. But research should nevertheless, be considered a very important part of the teacher's training, on account of the habits of thought and work which such training inculcates.

In the discussion of the paper, Professor Gager, of Ithaca, took exceptions to the need of strictly research work in the preparation of the high school teacher. He agreed that the teacher should become familiar with research methods, but thought the knowledge obtained was not often of practical value in the profession. He was, therefore, in favor of acquiring the methods by investigating subjects of direct aid in science teaching, which, though not new to science, were new to the teacher.

Others agreed with the paper that there could be no substitute, in the teacher's preparation, for genuine research, for the following reasons: Original contributions to the knowledge of a subject increase the student's permanent interest in the subject and inspire respect for him as a teacher. He becomes fitted to weigh the contributions of others and to understand through what stages the science has been developed.

On the second day of the session, Mr. M. Smith Thomas, of Le Roy, took up the subject of "Experimental Physiology in the High School." He particularly treated of laboratory methods which he found practical.

Discussion of the paper brought out quite varied opinions as to the relation of physiology, both theoretical and experimental, to the laboratory course. It was pointed out that an experimental course in pure physiology is entirely too difficult for high school pupils. Indeed, it is sometimes found a stumbling block to college students with two or three years' of previous laboratory experience.

The removal of physiology from the high school to the grades was advocated on the ground that five or six years' of physiology study in the grades give opportunity for as much of the science as is not too advanced for the high school and prevents the distaste for more of the subject, which the pupil often feels on taking it up in the high school.

It was the opinion of the speaker that simple dissecting, microscopic work, including the mounting of slides from material already prepared, experiments illustrating the action of digestive ferments and the like were not too advanced for the seventh and eighth grades.

The more general view seemed to be that experimental physiology, even in the high school, should consist, to a considerable degree, of observational work and demonstration by the teacher, assisted by pupils.

Mr. C. N. Cobb, of the Regents' Office, thought that too little emphasis is laid on laboratory work in physiology by the state, owing, perhaps, to the traditional methods clustering about physiology teaching, the difficulty of providing suitable experiments, and the relegating of physiology teaching to other than science teachers.

Owing to the diversity of view as to the best laboratory course for high school physiology, it was voted that a committee be appointed to formulate, for the association and teachers of the state a laboratory course suitable for high schools. Mr. Cobb, Miss Katherine S. Wetmore of Rochester, Prof. A. D. Morrill of Hamilton College, Mr. J. S. Kingsley of Newark Valley, and Mr. Thomas of LeRoy were appointed by the chairman.

Reported by E. G. CONGDON, Secretary of the Section.

Correspondence.

EDITOR SCHOOL SCIENCE:

In the article on "What Chemistry Shall Be Taught in the High School and How It Shall Be Most Effectively Taught," in the February number of SCHOOL SCIENCE, the writer says some excellent things about chemistry teaching. But it seems to me that he goes too far in his discouragement of attempts to teach chemistry with unsatisfactory equipment. Many a school with very fair facilities today would still be without a laboratory if a beginning had not been made in a small way. One of the best things that several of our newer text books have done for chemistry teaching is the description of more simple methods of performing the essential experiments. Splendid work can be done in chemistry with a class of sixteen pupils in a room furnished with tables, some shelves and a sink. My first class went through a very fair laboratory course in a room with no sink. No elaborate pieces of apparatus are necessary, except some balances on which weighings to centigrams can be made. While ventilating hoods are very important, if the room has good ventilation, all of a good high school course can be given without them, and that, too, without living half the time in a poisoned atmosphere, as we are at present demonstrating in our high school, where we enroll about one hundred pupils in chemistry. We have no ventilating hoods and our laboratory has been unpleasant from bad odors but once or twice this school year.

Fine equipment is desirable, but don't let us discourage the teachers in small schools from making the best of what they have, and trying for more.

HARRY CLIFFORD DOANE.

Central High School, Grand Rapids, Mich.

This number completes the second year of the existence of **SCHOOL SCIENCE.** The reception accorded two years ago to the magazine was most encouraging, and the continued and growing interest taken ever since has been most gratifying. The prosperity of a journal devoted to the interests of science teaching is a good criterion of the excellence of that teaching and of the character of the teachers.

SCHOOL SCIENCE can best thank its supporters by rendering itself more worthy. A number of interesting features for the third volume has been arranged for. The **MATHEMATICAL SUPPLEMENT** will certainly prove an invaluable aid to all science teachers. The **REPORTS OF MEETINGS** will be more prompt and more detailed. The other Special Features will be in every possible way improved.

SCHOOL SCIENCE hopes to double its sphere of influence during the next year, and earnestly bespeaks the active co-operation of every one who has the interests of good science teaching at heart.

To avoid fine, this book should be returned on
or before the date last stamped below

50M—9.40

BASEMENT

THIS BOOK
NOT CIRCULATE